



DEPARTMENT OF SCIENTIFIC
AND INDUSTRIAL RESEARCH

FOREST PRODUCTS RESEARCH 1953

LONDON: HER MAJESTY'S STATIONERY OFFICE

1954

THREE SHILLINGS

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL
RESEARCH

REPORT OF THE
FOREST PRODUCTS RESEARCH
BOARD

WITH THE REPORT OF
THE DIRECTOR OF FOREST PRODUCTS
RESEARCH

FOR THE YEAR
1953

LONDON: HER MAJESTY'S STATIONERY OFFICE
1954

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1953

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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH,
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REPORT OF THE FOREST PRODUCTS RESEARCH BOARD FOR THE YEAR 1953

*To the Lords of the Committee of the Privy Council for Scientific
and Industrial Research*

MAY IT PLEASE YOUR LORDSHIPS,

WE, the Forest Products Research Board, beg leave to present our report for the year ending 31st December, 1953.

The progress of the work has largely been along the lines of recent years, and although steady and relatively uneventful it has, we are gratified to report, been very satisfactory. The continuing major project of evaluating new tropical species of likely importance has gone on hand in hand with the increasing amount of testing and assessment of sample consignments of home-grown species from the plantations of the Forestry Commission. The development of the latter scheme has brought a yet closer liaison with the Commission's officers, both in the Laboratory and in the field.

The provision of data and advice to all branches of the timber-using industry has gone on actively. The great volume of advisory work has been stimulated and supported not only by the indirect approach by normal methods of propaganda, such as lectures, the press, and broadcasting, but also by the direct means of personal contact. Indeed, we may say that the success of the Laboratory in putting its knowledge and experience at the disposal of industry rests largely upon the personal contacts made and maintained by the officers of the various sections with firms operating in their particular fields. This year there has again been no remission in the volume of advisory work by mail, telephone, visits or visitors. The number of enquiries dealt with by letter or report was 5,923 and the number of leaflets issued in reply to routine queries was 31,466.

In his report for last year, the Director recorded that the number of overseas visitors to the Laboratory had shown a marked increase. During this year the further increase has been remarkable; up to September 108 visitors (as against 69 in 1952) from 34 different countries or colonies having come to see the work in progress.

The long-term research work, notwithstanding that it is being carried on at least to some extent in all sections, still goes forward more intermittently than we would wish to see, mainly because the timber testing projects, the advisory work and the size of the staff complement continue to restrict the time available for basic research. From time to time we have drawn your Lordships' attention to our uneasiness in this respect, and we have again reviewed the position to see if it could be ameliorated.

The programme of timber tests is a continuing commitment, which involves most of the sections of the Laboratory, and it cannot be curtailed. The advisory work, which began to mount rapidly during the war years, did not, as was

expected, become steady in the immediate post-war years but on the contrary rose continuously, so that even if it had been possible to recruit the staff estimated for the immediate post-war requirements the proportion of the available time absorbed by advisory work would still have been large. On the present complement of staff the burden has become very heavy. Yet the advisory work must not be curtailed but must indeed be fostered.

The advisory work, which is carried on not only by the section of External Relations but also by the staffs of all the sections in their own industrial fields, is the greatest single medium for furnishing industry with the information it requires. The trends in industrial requirements disclosed by the advisory work also have a profound influence on the technical research programme. Fundamental and long-term technical projects, which it is true, can be held over temporarily without loss of industrial efficiency, have therefore had to give way, and we have reluctantly accepted this position for some years. We are aware of the present necessity for economy which has imposed rigid limitations on the recruitment of staff. Notwithstanding this, we feel that we must again reaffirm that in our opinion there can be no effective improvement in the research position until the scientific staff, particularly in its scientific officer grade, is reinforced. Moreover, the postponement of the basic research should not continue for too long, because sooner or later the want of its pursuit must impair not only the technical efficiency of the Laboratory's service but also the training of its junior officers in research methods.

The progress of the work in the various sections is referred to in the Director's report and here we need only draw your Lordships' attention to points of general interest in the year's work.

TROPICAL TIMBERS

Requests from industry on the best timbers for use as substitutes or for new uses are still very numerous, and the collection and dissemination of data on new species go on unremittingly. A typical and interesting investigation was that carried out in collaboration with the industry on the possibility of using Commonwealth timbers for making matches.

Since the last edition of the Handbook of Empire Timbers was published, many new timbers have been examined and many old ones re-examined. A new Handbook is in preparation which will bring up-to-date the information in the old one and include interim publications and data on the newer timbers. It will deal with some 270 species of home-grown and exotic hardwoods.

WINDBLOWN TIMBER IN SCOTLAND

Following the devastation to Scottish forests caused by the gales in February, 1953, many enquiries were received regarding the treatment of the blown timber pending its conversion, and an advisory note was prepared and circulated. The opportunity was taken to procure from the devastated area specimen logs for test which otherwise would not have been available, and to send an officer to join the Forestry Commission's entomological survey team operating in the gale-damaged coniferous woods on Deeside.

KILN SEASONING

In addition to the continuing work on the kilning properties of different species, tests on the effect of air speeds and relative humidity on drying rates

have been carried out. Air speed has its greatest effect during the drying period when the wood is green, but its effect decreases as the transfusion rate of the moisture in the wood becomes the limiting factor.

Although superheated steam as an agent for the kiln drying of timbers has been utilized from time to time, and recent developments have made possible the commercial drying of softwoods, knowledge of its use in the kilning of hardwoods is still limited. Tests on the behaviour of light-weight hardwoods kiln dried in superheated steam have shown that at least some species can be dried rapidly with little increase in degrade over that incurred in kiln seasoning to the orthodox schedules.

WOOD BENDING

Work is in progress on the production of large-section laminated bends such as are used in boat building. Several of the bends have been successfully made and tested, and further work to improve the technique is now in hand.

TIMBER MECHANICS

It has been possible during the year to devote more time to the basic projects on the strength properties of timber. The investigations into the strength of struts and of plywood and into the effect of temperature on strength are well advanced, and the study of the strength of nail joints has been completed. A detailed investigation into the effect of immersion in hot water on the compression strength of English oak shows that the compression strain increases steadily as the temperature of the water is raised to the boiling point. Thus in the making of bends, where the compression strain is an important factor, immersion at 100°C can be expected to produce more satisfactory bends than treatment at lower temperatures.

PLYWOOD INVESTIGATIONS

The tropical experiments at Port Harcourt, Nigeria, on the durability of adhesives in beech plywood under conditions of full weathering and of semi-outdoor exposure have now been running for three years—long enough to yield preliminary comparisons with similar experiments in England. The results show that deterioration where it occurs has proceeded more rapidly under tropical than under temperate conditions, and that the order in which the glues fail is the same in both climates.

Plywood, when exposed to the weather, develops fine cracks, or checks, on the surface. An allied and troublesome problem in the manufacture of veneered products is the development of surface defects on polished faces. To make possible an analysis of the general development of such defects, two investigations have been carried out. In one the exposure of plywood to the weather has yielded a grading of species for proneness to checking; in the other the basic causes of surface defects in finished articles have been elucidated.

Other plywood projects in hand during the year concern temperature penetration and moisture migration in plywood, a matter of importance in the operation of pressing; and further studies in veneer spooling, clipping and drying.

ADVISORY PANELS

The Plywood Research Panel is now in its fifth year, and its sister panel, the Adhesive Makers' Panel, in its ninth. These informal industrial panels, which have met as usual during the year to review and discuss the plywood research programme, continue to be a most valuable link with industry. Our grateful acknowledgement is again made to the voluntary members and their Associations and to those members of Government departments who serve upon the Panels.

SLEEPER INVESTIGATIONS

Two service trials of preserved sleepers are being carried out in co-operation with British Railways. The older one, which has been running for some 20 years, is nearing completion as the sleepers are being gradually removed during track re-laying. One important conclusion which has emerged is that in fast lines the mechanical degrade of the sleepers is a much more common cause of deterioration than fungal decay. The newer project concerns the possible use of Canadian western hemlock, which may have to be used on an increasing scale for sleepers in place of Douglas fir.

ENTOMOLOGICAL WORK

Because of their immediate importance, priority has again been given to studies on the common furniture beetle and the house longhorn beetle. With the former, work has been done on the suitability of timbers and plywoods for breeding work and of different surfaces for egg-laying observations. With the house longhorn beetle, surveys have been continued in infested areas and a study has been made of the effect of temperature and humidity on the hatching of the eggs, as variations in these conditions appear to have an important bearing on the distribution and spread of attack in this country. Life-history studies of the insect show that the rate of larval growth is also closely related to temperature and humidity conditions.

Attention has again been given to the best means of combatting the infestation of H.M.S. *Victory* by the death-watch beetle. Following inspections and consultations, it has been decided that fumigation under the special conditions peculiar to H.M.S. *Victory* is practicable, and a recommendation for treatment by fumigation has been made jointly by the Forest Products Research and the Pest Infestation Laboratories.

The organization and training of the West African Timber Borer Research Unit has been completed, and two members of the team have left for the Gold Coast, the third to remain at the Laboratory to carry on the fundamental investigations.

WOOD ANALYSIS

In addition to its importance in pulping technology, the knowledge of the wood polysaccharides will certainly be of value in investigations on the breakdown of wood by chemicals, fungi, and insects. During the year further progress has been made in examination of the hemicelluloses; hemicelluloses B and C have been isolated from beech wood, and their structure will now be studied. A polysaccharide containing mannose and glucose units only has been isolated from Sitka spruce, and a detailed investigation of the saponin from morabukea has been undertaken.

MEMBERSHIP OF THE BOARD

On the completion of their periods of membership, Col. A. H. Lloyd and Mr. H. Nuttall retired from the Board in March, 1953. We wish to put on record our appreciation of the services they have rendered to the Laboratory. We are glad to welcome Sir Edward Monkhouse and Mr. H. A. Collinson as their successors, and to record that on the recommendation of the Forestry Commission, Mr. A. H. Gosling has been reappointed as their official member for a further period of four years.

R. G. BENNETT,
Chairman.

17th March, 1954.

REPORT OF THE DIRECTOR OF FOREST PRODUCTS RESEARCH FOR THE YEAR 1953

INTRODUCTION

During the year 1953 no new developments of major importance in the work of the Laboratory have taken place, nor has the national timber situation called for any significant change of policy. The permitted complement of staff remains substantially unaltered, and the allocation of resources between advisory work, routine investigations and long-term research projects has been roughly as in previous years. The demands of industry for data and advice still constitute a heavy, albeit a welcome burden. The testing and evaluation of new timbers from the Colonies continue, but during the year a somewhat increased proportion of available time has been taken up in testing home-grown material from various of the Forestry Commission's plantations and from areas in Scotland affected by the gales in the spring. In coming years, as on the one hand the testing of the more prominent overseas species is accomplished and on the other the Forestry Commission's plantations approach maturity, the proportion of time allocated to the home-grown species may be expected to increase.

Our relations with outside bodies and institutions, with private firms, other government departments and the general public remain excellent, and pleasant collaboration continues on co-operative projects in both the academic and the applied fields. As in previous years, also, valuable liaison work has been done through the senior members of staff, who have placed their expert knowledge at the disposal of the numerous advisory and technical committees on which they serve.

GENERAL

Staff, Buildings and Equipment

The structure and proportions of the staff complement remain essentially the same as in 1952, and no additions or major alterations have been made to the Laboratory's buildings.

Heavy equipment has been increased by the acquisition of a veneer slicer, which mounts a 72-inch knife and is capable of accommodating a flitch 36 inches square. It is being installed in Composite Wood Section.

Tours Abroad

The Officer-in-Charge, Timber Mechanics Section, was a member of a European mission, organized under the auspices of the Mutual Security Agency, which visited the United States during the early months of the year to study developments in the manufacture and use of laminated timber products. A very extensive series of visits had been arranged to enable the mission to see lami-

nation work in all its aspects, and in view of the interest in this country in developments in this field, the tour proved to be one of great value. Grateful acknowledgement is due both to the Productivity and Technical Assistance Division of the Mutual Security Agency and also to all those in the United States who by extending hospitality and putting their technical resources at the disposal of the party ensured the success of the mission.

The Officer-in-Charge, Chemistry Section, visited Sweden in July-August, 1953 in order to attend the 13th International Congress of Pure and Applied Chemistry, and a meeting of the F.A.O. Panel on Wood Chemistry, both of which were held in Stockholm. A Symposium on the Chemistry of Wood and Wood Constituents formed part of the proceedings of the International Congress, and these gatherings provided a useful opportunity for meeting workers from other countries having similar interests. A number of research laboratories and industrial plants were visited, and profitable discussions held, in particular on the subject of fibreboard production.

The Officer-in-Charge, Entomology Section, accompanied by Mr. W. E. Webb, senior officer of the newly-formed West African Timber Borer Research Unit, visited French and Belgian entomologists to obtain information on related investigations in progress in their West African colonies. The Laboratory has a particular interest in this work as one member of the West African Unit will remain at Princes Risborough to work on some of the more fundamental aspects of the borer problem.

Publications and Records

New publications issued through H.M. Stationery Office during the year were four in the bulletin series, and the Annual Report for 1952. Bulletin No. 26 "An Atlas of End-grain Photomicrographs for the Identification of Hardwoods" gives illustrations, at a magnification of 10 diameters, of the timbers included in Bulletin No. 25 "Identification of Hardwoods: A Lens Key" and thus provides, in the absence of authentic specimens, representative material by which to verify identifications by the lens key. Bulletin 27 deals with the performance of circular plate rip-saws. Bulletin No. 28 "The Strength Properties of Timber" records the results obtained from standard tests, made at the Laboratory over the past twenty-five years, of one hundred and twenty-two native-grown and imported softwoods and hardwoods. Bulletin No. 29 "The Strength of Plywood. Part 1. The Comparison of 3-ply Woods of a Standard Thickness" is the first report of strength tests of such material, from twenty-five species.

A revised edition was issued of Leaflet No. 43 "Spray Treatment for the Prevention of *Lyctus* Attack in Sawn Logs," and thirty-two papers (see Appendix II) were published in the scientific and technical press; and twenty-one reports, mainly on the subject of plywood and plywood adhesives, were prepared for limited circulation.

Revision of the Handbook of Empire Timbers has been put in hand with a view to bringing up-to-date the information on both Empire and home-grown commercial hardwoods and bringing them under one cover. Many new timbers have been tested and described in recent years, and the new edition of the Handbook should include some 270 types.

The Advisory Service

The number of enquiries answered by letter or report, which is taken as a measure of the volume of advisory work during the year, was 5,923. The number of technical visitors and telephone enquiries has been correspondingly large, and the percentage of staff time required to deal with the advisory work remains high.

The number of leaflets issued in reply to standard enquiries was 31,466.

PROGRAMME OF RESEARCH

WOOD STRUCTURE

Collection of Timber Specimens

It is a pleasure to acknowledge the co-operation of all who have contributed to the Laboratory's reference collection of timber specimens. In the past year collections have been received direct from the Forest Departments of Bolivia, Jamaica, Tanganyika and Uganda and others by way of the Imperial Forestry Institute, Oxford. The Royal Botanic Gardens, Kew, sent specimens taken from exotic trees and shrubs grown in the temperate house. In addition, many valuable samples of commercial timbers have been received through trade channels. The number of specimens added to the collection during the year was approximately six hundred.

Research Projects

Advisory work and the routine investigation of new species have greatly restricted the amount of time available for the longer term projects in Wood Structure. Examination of timbers has, however, been carried on as circumstances have permitted and suitable material has accrued.

Structure and Quality

Timbers are generally graded mainly with respect to certain fairly obvious "standard" defects such as knots, checks, splits, worm-holes, discolouration and decay. But timber free from all such defects may still exhibit a wide range of variation in technical properties owing to growth features which affect the texture, density and strength of the wood. For instance ring-porous timbers such as oak and teak, by reason of their structure, are unusually variable in this respect. It is not always realized that, for certain purposes, especially where strength is important, further selection of graded timber may be required if the material is to be used to the best advantage. This is where a working knowledge of the elements of wood structure is of value.

In some cases it is in fact reasonably practicable to assess the quality by visual examination in the ordinary course of conversion and manufacture. This is illustrated by a practical problem recently referred to the Laboratory. A firm manufacturing chairs normally made of European oak or beech started using Japanese oak which is on the average somewhat lighter in weight and correspondingly weaker. Breakage of a few chair legs in transit suggested that the use of Japanese oak in this way would have to be abandoned as such breakages would damage the reputation and trade of the firm out of all proportion to the value of the few defective chairs. By sampling the firm's stock of the timber it was found that the density ranged from $30\frac{1}{2}$ to 50 lb./cu. ft. in the seasoned

condition (a selection of the samples is shown in Plate 1). From a consideration of mechanical test results a reasonably safe lower limit of density was determined and from this, by statistical methods, the proportion of boards unsuitable for legs was estimated to be about 20 per cent.

Using selected pieces as standards it was possible for the operatives concerned to recognize visually sub-standard timber which could then be set aside and utilized for the less highly stressed components. In this way the manufacturers' problem was brought into proper perspective and he was enabled to use the timber in a satisfactory and economic manner.

It is not always possible, however, to assess the strength of timber with sufficient accuracy by inspection. There has been an increasing number of instances of ash proving defective in service, particularly when used for purposes demanding high resistance to shock load, as in sports goods and the handles of striking tools. Some of the defective pieces have been of slow growth and low density, indicating a lack of care or experience in selection⁽¹⁾. Frequently, however, the wood has been of excellent quality as judged by density and gross structural features, but micro-staining tests have indicated that the composition of the cell walls is of a type previously found to be associated with low strength⁽²⁾. There is, as yet, no means of recognizing defective timber of this kind short of mechanical test or microscopic examination, but a start has been made on exploring the variation in cell-wall composition in relation to site factors and the growth of the tree. It is intended to check a selection of these microscopic observations by means of mechanical tests on matched specimens. The investigation is likely to be a lengthy one but it is hoped that its results will be applicable to the everyday selection of ash for industrial purposes.

Matchwood Investigation

In collaboration with other Departments and with the match industry, investigations have been proceeding on the possibility of using Commonwealth timbers for making matches, either in the United Kingdom or in the Colonies. Much technical information has been assembled, including the results of tests carried out on trial consignments of timbers specially procured from overseas. It has been concluded that, with the possible exception of *Pinus radiata* from New Zealand, none of the timbers tested is likely to prove acceptable to the British match industry for use in the automatic machinery employed in the United Kingdom. In some instances the wood was found to be too hard or too cross-grained, in others the colour or burning properties were unsatisfactory, but the main cause of rejection was deterioration of the timber in transit owing to splitting and fungus or insect attack. There is reason to believe, however, that some of the timbers tested may be suitable for the manufacture of matches in the Colonies where logs could be supplied to the factory in a reasonably fresh condition.

Advisory Work in Wood Structure

A large proportion of the enquiries has been concerned, as usual, with the identification of commercial timbers, frequently involving advice on quality or suitability for particular purposes. A common type of enquiry entails checking the identity of imported timber; it is evident that some overseas shippers are not so

⁽¹⁾ See For. Prod. Res. Leaflet No. 37 (1944). Selecting Ash by Inspection.

⁽²⁾ CLARKE, S. H. Application of Micro-chemical Tests in Assessing the Quality of Ash Timber. *Nature*, 1935, 135, 919.

careful as they might be in ensuring that consignments are of the correct species. It can be understood that various species of the mahogany family, such as sapele, utile, gedu nohor, guarea, African walnut and *Khaya*, are sometimes confused, but there is scarcely the same excuse for shipping albizzia and okan as iroko, bombax as makoré and agba, okwen as idigbo, or canarium as African mahogany and African walnut, to mention a few examples.

Although there are not so many strange timbers coming into the country as there were three or four years ago, a good many of the hardwoods actually on the market or being offered to importers are unfamiliar to the trade. For many of them published information is not readily available and there has been a steady stream of requests for particulars of specific timbers which can be satisfactorily answered only by letter. Unusual enquiries in the course of the year have had to do with the timber used for the masts of Arab dhows at Port Sudan (a species of *Palaquium* probably from the west coast of India), a "boxwood" rule made in China (a species of maple) and weavers' shuttles from Japan (*Diospyros kaki*).

Advice on timbers for laboratory bench tops has been given to the British Standards Institution Committee on Laboratory Furniture and Fittings. A good deal of information on this subject has been accumulated from contacts with manufacturers and users supplemented by test data on the properties of the timbers concerned. In addition opportunity has been taken from time to time during the growth of the Laboratory to install bench tops of various Colonial timbers. Their suitability for the purpose has now been reviewed and an up-to-date assessment has been made of the properties needed in a bench timber to ensure satisfactory service under various conditions of use.

The number of enquiries involving a written reply amounted to 643.

SEASONING

Kilns and Kiln Seasoning

The large kilns have been used during the year for the drying of experimental loads of African mahogany, obeche, Douglas fir, poplar, ash, mansonia, oak and jelutong. The 3-in. thick jelutong seasoned satisfactorily at relatively high temperatures with little degrade, though the movement of moisture from the centre of the planks outwards was found to be rather slow. The ash, which had been partly air seasoned, was badly distorted initially but as a result of careful piling and kiln drying this distortion was greatly reduced. The mansonia, which was 2½ in. thick, seasoned slowly but with virtually no degrade.

In co-operation with a firm of battery manufacturers which has been experiencing troubles in the use of improperly seasoned abura, two loads of 1-in. abura were kiln dried and carefully conditioned to provide material from which to judge whether this species would prove satisfactory for the making of battery boxes. The wood seasoned well with little degrade and the firm has reported that the results so far obtained with the material are most promising.

In the smaller kilns, experimental loads of canarium, serrette, okwen, Turkey oak, sepetir, African mahogany and cherry have been dried. Canarium seasoned with less degrade than was expected and appeared to be tolerant of fairly high temperatures. Turkey oak on the other hand proved to be most refractory and reacted most unfavourably to even a mild kiln treatment.

In connexion with the series of tests on the seasoning of home-grown softwoods, loads of western red cedar, European spruce and a further load of Sitka spruce have been dried.

The western red cedar was dried at a very low temperature and although the drying period was long, the final condition of the timber was excellent and virtually no collapse, such as had been very pronounced on a previous load of this species, occurred. The consignment of Sitka spruce, however, which was from timber blown down in East Scotland, though dried at the same schedule as similar material previously obtained from West Scotland, was found to be most prone to collapse.

The Kiln Drying of Home-grown Sitka Spruce

In co-operation with a firm formed for the milling and marketing of Sitka spruce grown in Scotland, tests were carried out to obtain data for the design of progressive kilns for the rapid drying of this timber. A consignment of Sitka spruce supplied by the Forestry Commission was obtained from the West of Scotland. This was converted into 2-in. and 1-in. boards and subjected to unusually severe drying conditions in the model and intermediate size kilns.

It was found that although the bulk of the material was very tolerant of severe drying conditions, occasional trees produced material that was very prone to collapse or surface "ribbing" during drying. It was shown also that although the intensity of collapse tended to increase with increasing temperature, some of the wood tended to collapse even in air drying. The optimum schedule appeared to be one starting at a temperature of 120°F and finishing at 170°F with relatively low humidities throughout. By this treatment, the 2-in. material could be seasoned to about 18 per cent in around six days and the 1-in. in approximately three days with virtually no splitting and with no more distortion than might be expected from the use of the milder schedule previously recommended. It was not possible to prevent collapse in material from logs susceptible to this form of degrade, but the low initial temperature proved effective in limiting its intensity. Further work will be carried out on this species as opportunity permits.

Tests on the Effect of Air Speeds on Drying Rates

Tests were carried out in the new model kiln to determine the effect of air speeds and relative humidity on the drying rate of 1-in. beech.

The effects of these factors on the drying rate of samples situated on the air inlet side of a pile were investigated and a constant-temperature schedule using humidities normally recommended for drying beech was employed. The fan was run to produce speeds of $2\frac{1}{4}$, 5 and $11\frac{1}{2}$ ft./sec respectively through the 1-in. air spaces and, to overcome matching difficulties, the samples were rewetted after each run by a water impregnation treatment.

It may be seen from the drying curves (Fig. 1) that the times taken to dry to 12 per cent moisture content were 7, $5\frac{1}{4}$ and 4 days respectively. Air speed had its greatest effect upon drying rate during the relatively free drying period when the wood was green, but from 30 per cent moisture content downwards when the transfusion rate through the wood became the main factor in determining drying speeds, the effect of air speed over the wood surfaces on drying rates was small.

A fourth run was carried out with an air speed of 5 ft./sec and the air

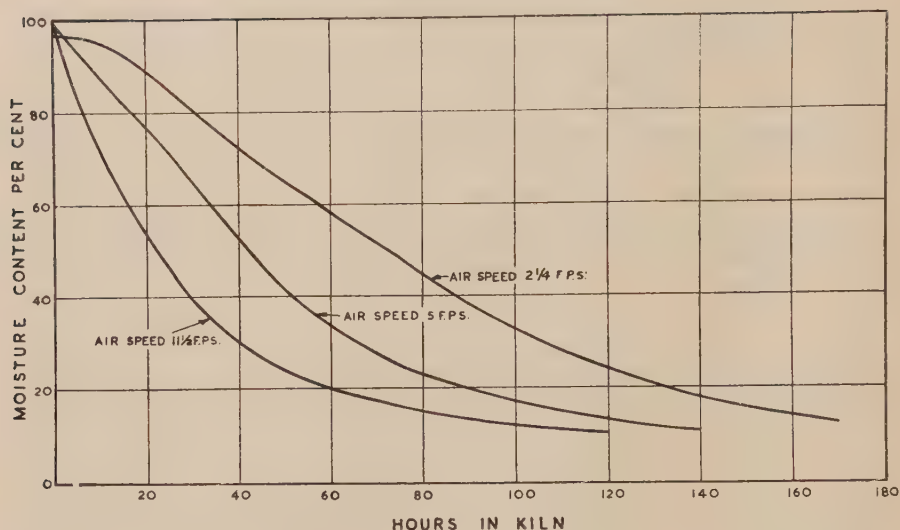


FIG. 1. THE INFLUENCE OF AIR SPEED ON THE DRYING RATES OF 5×1 -in. BEECH BOARDS ON THE INLET SIDE OF A KILN STACK

humidities were adjusted to produce virtually the same drying rate as that produced previously with an air speed of $11\frac{1}{2}$ ft./sec. It was found that this could be done by applying humidities some 10 to 15 per cent lower during the early stages and approximately similar humidities after the moisture content had fallen to about 45 per cent. The results of these tests tended to confirm the view that an increased air speed reduces the thickness of the film of cooler, more humid air that tends to accumulate over the surfaces of relatively free drying material and so in effect to reduce the surface air humidity. A relationship between air speeds and the relative humidity of the incoming air was also established for a particular set of conditions.

Further series of tests designed to determine the influence of air speed upon the drying rates of other species and also on the drying lag across a wide pile are in progress.

Seasoning in Superheated Steam

Following the fairly satisfactory results already reported (1952 Report p. 12) in the tests on the drying of Scots pine in superheated steam it was decided to investigate the behaviour of some light-weight hardwoods when dried by a similar treatment.

Abura and obeche were selected as suitable species and matched loads of 1-in. boards were dried to the schedules normally recommended for them (schedules 7 and 8 respectively) and in steam superheated to 110°C .

Both species in superheated steam dried in approximately one-third of the time taken in normal kiln drying and only slightly greater checking and distortion resulted from the high temperature treatment. Some, though not very pronounced, collapse occurred in certain boards, however, and the extent of this is illustrated in the photograph of sections of matched boards dried by the two methods (Plate 2).

The Kiln Operators' Course

The value and importance, both to the timber trade itself and to the country as a whole, of wood being adequately and carefully seasoned before use were fully realized by the Laboratory from its earliest days. It was also clear that in order to attain this end it was necessary not only to have well designed and efficient drying kilns but also to ensure that they were operated intelligently and conscientiously. Indeed it was felt that the skill of the operator might be a more important factor than the efficiency of the kiln, since he could do much to minimize the shortcomings of an imperfect design.

As a result, a year or two after the Laboratory was established at Princes Risborough, it was decided to grant facilities to industry for the instruction of those responsible for the operation of timber-drying kilns. No attempt was made at first to arrange a set course of instruction and employers were encouraged simply to send their actual or prospective operators at times mutually convenient. The students generally attended individually and stayed for a few weeks, during which time they observed such kiln runs as were in progress at the time and received such instruction as could be afforded.

During 1928 nine trainees were dealt with in this way, and the informal arrangement continued for about ten years. The number of students sent for instruction increased, however, as time went on and by 1938 the almost continuous trickle of men coming to the Laboratory for training began to cause some embarrassment to the staff of the Seasoning Section by interfering unduly with the work on their research projects.

It was therefore decided to institute a formal course of instruction of a week's duration in place of the existing arrangement, the number of students being limited to twenty and the course being held once, or at the most twice, a year. To ensure continuity the instruction was placed in the hands of one officer, who incidentally has now, if we include the original informal tuition, completed twenty-five years of instruction in kiln operation.

The first class of twenty students attended in February 1939 and a further course was arranged for October of the same year, but owing to the outbreak of the war only seven students were able to attend.

Very soon, however, war conditions caused a greatly increased demand for seasoned timber and in order to meet this demand Timber Control embarked upon an extensive kiln-building programme. As a result, the need for skilled operators to run the new kilns became urgent and by the autumn of 1943 had become so great that it was necessary to hold the courses in kiln operation as frequently as every fortnight.

Although the urgency of the war days has gone, the demand for training has continued, and courses each attended by about ten students are now being held at intervals of from six to eight weeks. Nearly 800 persons have by now received instruction, and among the number have been not only those actually responsible for the operation of the seasoning kilns, but also members of the industry up to executive level. In recent years also, an increasing number of students from the Colonies have taken the course.

The art of kiln operation cannot, of course, be acquired in a short course of instruction, however intensive, but the great and incalculable benefit which has accrued both to industry and to the Laboratory comes from the continued contact maintained after the trainee has returned to his job. He has been taught

how to deal with his more trivial problems, and he turns to the Laboratory when more serious troubles arise; and what is as important, in those places where an old trainee is in charge, the staff of the Laboratory are assured of a cordial welcome and fruitful discussion on their visits. A photograph of a phase of the instruction is shown in Plate 4.

Wood Bending

Work has been started on a project to investigate the technique and various factors involved in the production of large section laminated bends such as are used in boat-building. Three laminated oak stems 9 in. x 5 in. in cross-section of the shape used in Admiralty harbour launches have been made. Pressure on the glue layers was obtained by means of clamps fitted with quick-release split nuts designed at the Laboratory which have proved very satisfactory.

A resorcinol resin glue was used but it was found that when this was set and the assemblies conditioned at room temperature there was a tendency for the wood to check and the bend to delaminate. These troubles were largely overcome by setting and conditioning the bent assembly in a kiln at 150°F and 75 per cent humidity. On completion each bend was subjected to strength tests. A report on the work is in preparation.

As a result of experience gained in making these stems, an improved bending technique has been developed which consists essentially of employing a female jig to the ends of which are fitted stepped end-stops. One end of each individual thick lamination is made to bear against one end-stop and the other end forced into its appropriate position by the thrust of a pneumatic ram, thus causing the piece as a whole to bend roughly to shape. Clamps are then applied at intervals along the assembly in the normal manner to provide the requisite lateral pressure.

Attempts to "set" these large bends by radio frequency heating have so far proved difficult mainly because of the disturbing influence that the metal clamps have upon the electrical field. Further work is in progress.

Bending Tests

The routine testing of timbers to determine their bending properties has been continued and data on some nine different species obtained. Species tested included serette (*Byrsonima spicata*), wamara (*Swartzia leiocalycina*) and okwen (*Brachystegia nigerica*). None of the species tested could be recommended as substitutes for the well-known bending timbers such as beech, but sufficiently promising results were obtained with okwen to warrant its being further tested.

Standard tests have been carried out to determine the limiting radii of curvature of plywood made from six different species of tropical hardwoods including brown sterculia (*Sterculia rhinopetala*) and pterygota (*Pterygota kamerunensis*).

Continued interest has been shown by the furniture and other woodworking industries in the new process developed at the Laboratory for making plywood corners of small radius and an improved method has been evolved for ensuring a more uniform temperature on the bending jigs heated by means of low voltage currents in metal heating elements.

At the request of a firm a method of mass-producing bends containing re-entrant curves on a lever arm type bending machine has been developed.

Advisory Work in Seasoning and Bending

A matter of perennial interest to builders arose from the request of a joinery firm to make an inspection of softwood floors that had shrunk excessively in a large block of flats. It was found that much of the shrinkage was attributable to having allowed the wood to absorb an undue amount of moisture during the plastering operations, and this resulted in an overall expansion sufficient to cause crushing along the edges of adjacent boards. The compressive "sets" so induced tended to persist so that upon re-drying, the gaps which developed between the boards were in excess of the normal.

For the period 1st January to 21st September, 80 visits were made to firms interested in seasoning and bending.

The number of enquiries dealt with during the period was 950.

TIMBER MECHANICS

Testing of Timber for Comparison of Species

The testing of timber for the comparison of species continues. Strength data have been obtained for Yugoslavian whitewood, for ash from Salcey Forest, for kokrodua, agba, African mahogany and brown sterculia from West Africa, for mgongo, mkwaju, mjembe and muhimbi from East Africa, and for wamara and kurokai from the West Indies. Tests are in progress on home-grown Norway spruce, Sitka spruce, western red cedar and Douglas fir supplied by the Forestry Commission, on serrette from Trinidad, sepetir from Sarawak, and on canarium and okwen from West Africa.

The investigation to establish correlation between the schemes of testing for the 2-in. and 2-cm size test specimens has been completed. The data are now being analysed.

Four timbers from Jamaica have been tested with reference to their suitability for axe handles. A report on the investigation has been submitted to the Forest Department.

The Structural Use of Timber

Tests have been carried out, at the request of the manufacturers, on standard building units constructed from light timber sections and thin plywood. Each unit consists of a series of troughs at 16-in. centres with light timber sections $\frac{7}{8}$ in. by $4\frac{3}{4}$ in. at the top and bottom of each trough, and 4 mm gaboony plywood nailed and glued to these members as inclined webs. The units are of a standard width 5 ft. 4 in. but of different lengths, namely 24 ft., 20 ft., and 16 ft. and depths $11\frac{1}{2}$ in., 9 in., and 7 in., respectively. These were each tested, firstly as roof units over spans of 24 ft., 20 ft., and 16 ft., with a load of 25 Lb./sq. ft. which was maintained for 24 hours, and secondly to destruction over reduced spans of 20 ft., 17 ft., and 14 ft. as floor units. Each unit was covered with $\frac{3}{4}$ -in. chipboard for the latter test.

The distributed load was simulated by the application of an eight-point load across each unit through a system of pulleys and a continuous wire rope. Load was applied by hand-operated winches which tensioned the wire rope. The reactions at the points of support were measured by hydraulic capsules.

The largest unit showed a maximum deflection of about $\frac{3}{4}$ in. over the 24-ft. span under the uniformly distributed load of 25 Lb./sq. ft. The unit failed under a load of 105 Lb./sq. ft. when tested on the reduced span of 20 ft. as a floor unit.

Failure occurred at the scarf joints in the bottom flange members. The deflection of the 20-ft. unit under the roof loading was of the order of 0.6 in. Failure again occurred at the scarf joints in the bottom flange members under a load of 120 Lb./sq. ft.

The long-term loading experiments on four small glued trusses of 19-ft. $10\frac{3}{4}$ -in. span, which were begun in 1952 (Report for 1952, p. 16), have continued. Readings taken six months after the application of dead load show that the initial deflections have increased appreciably.

As part of the co-operative project with the Forestry Commission, consignments of Norway spruce, Sitka spruce and Douglas fir, from Drummond Hill, Drumtochty and Novar Estate, Scotland, respectively, have been graded and tested for strength in structural sizes. The Norway spruce is slightly less dense and about 10 per cent less strong and stiff than the Sitka spruce from Inverliever tested previously. The Sitka spruce from Drumtochty is about 15 per cent less dense than the Inverliever spruce and this difference is reflected in its strength properties. The Douglas fir is appreciably more dense and stronger than the different consignments of spruce tested and is comparable with the consignment of Japanese larch tested in 1951.

The Strength of Struts

The project started in 1952 for the testing of struts had as its main object the provision of data on both high and low grade material as short, intermediate and long struts. Over 500 Baltic redwood struts and small clear specimens matched with these struts have been tested and tests have also been made on high grade Douglas fir struts. Further tests are in progress on additional material selected from high quality Sitka spruce and from high and low grade Scots pine. The results of all the tests are being analysed.

The Strength of Transmission Poles

Limitations of supply of softwood poles for power transmission lines has turned attention to the possible suitability of wallaba from British Guiana. At the request of the Southern Electricity Board, a commercial shipment of wallaba has been sampled and a representative selection of poles has been subjected to the standard pole test with the object of providing basic strength data for design purposes. The results of the series of tests indicate that for an increase in weight of 80 per cent over that of the redwood pole, the bending strength and the stiffness of the wallaba show an increase of 66 per cent and 80 per cent, respectively.

The Strength of Connector Joints

Further tests have been carried out on timber connectors at the request of the manufacturers. A $2\frac{1}{2}$ -in. shear plate connector of new design has been tested using a hardwood, agba, for the test-piece members. Bolted joints with the same species have also been tested for comparative purposes, and some experiments have been made using a small $1\frac{1}{2}$ -in. square toothed plate connector in joint members of European redwood.

The Strength of Nail Joints

The programme of tests, begun in 1952, to determine the strength of joints with round wire nails has been completed. The investigation involved a study of

the effect of three variables on the strength of the joint, namely, (1) the type of loading, whether single or double shear, (2) the number of nails used to make the joint, and (3) the thickness of members joined. Three sizes of nail in common use were chosen for the tests and two-member and three-member joints were fabricated with each size of nail. All joints were tested in compression parallel to grain.

Preliminary examination of the results of the series of tests shows that the maximum load carried by the joints is directly proportional to the number of nails used within the range of 1 to 4 nails. The results indicate also that the nails when loaded in double shear give joints about 50 to 75 per cent stronger than when loaded in single shear. The strength of the three-member joints increases with decrease in the thickness of the centre member whilst the strength of the two-member joints increases with increase in thickness of the member receiving the nail point. All joints are extremely stiff initially, three-member joints with 2-in. 12-gauge nails giving a slip of 1/100 in. at half maximum load compared to a slip of $\frac{1}{4}$ in. at maximum load.

The Strength of Plywood

Work on the determination of the strength properties of plywood has continued throughout the year. A report⁽¹⁾ has been published on Part I of the investigation, which has as its object the derivation of fundamental strength data to enable comparisons to be made between different species.

Considerable progress on the study of the effect of geometry and thickness on the strength properties has been made. Samples of gaboon plywoods varying in thickness from $\frac{3}{16}$ to 1 in. have been tested in bending, compression and tension. Solid wood specimens taken from the ends of the billets from which the plywood was made have also been tested by standard methods. From the results of these tests the relationships between the strength of plywood and solid wood are being determined. These relationships when used in conjunction with the test results as published in Part I should enable fairly accurate estimates to be made of the strength properties of any plywood construction. The report on this second part of the work is being prepared.

Laminated Construction

A survey of available literature on laminated construction has been made, and an investigation to determine suitable design procedure for laminated members is being planned. Preliminary strength tests have been carried out on the three laminated oak bends, 5 in. wide by 9 in. deep, already referred to (p. 14), firstly to establish testing procedure and secondly to study the distribution of strain across a bent member under load (Plate 3).

The Effect of Immersion in Hot Water on the Compression Strain of English Oak

A detailed investigation has been carried out to determine the most suitable water temperature for the immersion of oak before bending. Compression strain is the principal factor which limits the radius to which wood can be successfully bent and any treatment which permits increased compression strain without fracture would therefore improve the bending properties of the wood.

⁽¹⁾ CURRY, W. T. The Strength Properties of Plywood. Part I. Comparison of Three-ply Woods of a Standard Thickness. *For. Prod. Res. Bull.* No. 29, H.M.S.O., 1953.

Stress/strain curves have been obtained for groups of matched oak prisms tested in compression after immersion for 30 minutes in water at various temperatures. The results show that compression strain is considerably increased by immersion in hot water and that the strains are greatest when the temperature of the water is 100°C. There is no significant difference in maximum stress for different groups of specimens. The strain, and also the stress, at proportional limit have been found to decrease as the water temperature is increased. Immersion in boiling water before bending can consequently be expected to produce more satisfactory bends than treatment at any lower temperature.

The Effect of Temperature on the Strength of Timber

Investigations into the effect of temperature on the strength properties of timber have been continued. Tests made on basswood in compression parallel to the grain over a temperature range of 25°-80°C and at moisture contents ranging from 7 per cent to that of the green state have now been completed.

The results indicate that at all moisture contents any increase in the temperature of the wood above normal atmospheric temperature is accompanied by a decrease in the maximum crushing strength and the modulus of elasticity; the temperature/strength relationship is approximately linear over the range investigated. The decrease in strength varied from 0.75 per cent to 1.14 per cent of its value at normal temperatures for each 1°C increase in temperature, depending on the moisture content of the material. At a given moisture content the effect of temperature on maximum crushing strength is in general directly proportional to the specific gravity.

Control of the temperature at the time of test was effected by enclosing the specimen and the compression cage completely within a double-walled cylindrical chamber and circulating water at a constant temperature between the two walls. Connexion between the compression cage and the straining mechanism of the machine was achieved by means of two rods working through glands at each end of the chamber. In order to prevent any change in moisture content during test each conditioned specimen was enveloped in a tightly fitting latex rubber coating before being placed in the testing chamber. By this means specimens at moisture contents as high as 20 per cent could be brought to and maintained at temperatures up to 80°C without any appreciable change in moisture content.

Investigations into the effect of temperature on the strength of basswood in tension perpendicular to the direction of the grain have also been continued. A test piece of uniform cross section was used and in order to grip it a metal block of the same cross-sectional area was glued to each end using a synthetic resin adhesive. At temperatures above about 50°C a weakening of the metal-wood bond was apparent with the particular adhesive used, and reliable results could not therefore be obtained at these higher temperatures. Over a temperature range of 20-50°C, however, the technique appeared to give satisfactory results. These indicated a linear decrease in strength with increase in temperature of the wood.

An investigation has now been begun to determine the effect of kiln drying by superheated steam on the strength properties of three species of timber.

Abrasion

Two hardwoods, red selangan batu from North Borneo, and "Kilimanjaro oak" (*Rapanea* sp.) from Uganda, have been subjected to abrasion tests to

determine their relative resistances to abrasive action. The red selangan batu appears to be best suited for the normal pedestrian traffic of domestic and public buildings and the Kilimanjaro oak with a high resistance to wear promises to be very suitable for all types of industrial and other heavy-duty floors.

Tests on serrette and sepetir to examine their suitability for heavy-duty flooring are in progress.

Miscellaneous

The testing services of the section continue to be in demand by industry and a number of *ad hoc* investigations have been carried out during the year under review. They include tests of a glued joint for chair seat blanks made up using various glues and cramping pressures; of reinforced decorators' platforms to determine their bending strengths; of various types of ski blades to determine resistance to shock loading; and of various plywoods and block-board to provide data on their strength properties. Tests have also been made on a limited number of Yugoslavian spruce pit props and also on consignments of Douglas fir, Japanese larch, and western red cedar props at the request of a firm of importers and of the National Coal Board, respectively.

Advisory Work in Timber Mechanics

The number of enquiries received during the year on miscellaneous aspects of strength and the utilization of timber for flooring amounted to 343.

WOODWORKING

Sawing and Machining Research

A report on the mechanics of sawing for band and circular saws has been prepared for publication. It contains an analysis of the cutting action of band and circular saw teeth, with the relationships established between the dimensions of the wood removed and the conditions of cutting, and includes a theory, based on studies of chip formation, concerning the resistance offered by the wood to the passage of saw teeth. Equations are derived for the energy consumption, maximum allowable feed speeds and other factors in terms of the cutting speed, shape, spacing and relative sharpness of the teeth and the strength properties of the wood. Information is also given on the influence of the cutting conditions on the rate of blunting of the tooth. The publication is intended to provide data for designing saws for specific requirements and checking the performance of existing saws. Some of the practical aspects of these matters were also published during the year as Bulletin No. 27, "The Performance of Circular Plate Ripsaws."

Research in planing has been continued and further knowledge has been gained of the relationship of cutting angle, spindle speed, number of knives in cut and feed speed to machine performance. The machine chiefly used in these studies is a four-sided planing machine, with variable spindle speed 1,000-6,000 rev/min, feed speed 10-200 ft./min and cutting angle 0-35°. Variation of this angle is obtained by the use of a number of four-knife and six-knife interchangeable cutterblocks, which have their knife seatings suitably machined to give the required angle, i.e. 0°, 5°, 10°, etc. This method of changing the cutting angle has been found the most satisfactory, as all other conditions of cutting can be kept constant. The results obtained to date from tests made on the timbers

beech and agba indicate that the nett power demand is not directly proportional to the feed speed, as its rate of increase lessens slightly with rise of the latter (Fig. 2). This effect becomes more noticeable when the cutting angle is reduced and considerably more power is required (Fig. 3). Analysis of the cutting action had already indicated this trend. For a given cutting angle, spindle speed and feed speed, it has also been found that less power is required when the number of knives in cut is reduced. In tests on beech for example, with 30° cutting angle, spindle speed 4,000 rev/min and feed speed 50 ft./min, the nett power was reduced by 25 per cent and by more than 50 per cent in using four and two knives respectively instead of six, and by about 75 per cent with two knives instead of four.

A preliminary study was made of the effect of alteration of cutting angle and shear angle on the finish produced in wood turning of surfaces normal to the axis of rotation.

Investigations have been continued on the boring of quarter-sawn and flat-sawn material from various species, the torque and thrust being measured at different spindle and feed speeds. The latter conditions control the thickness

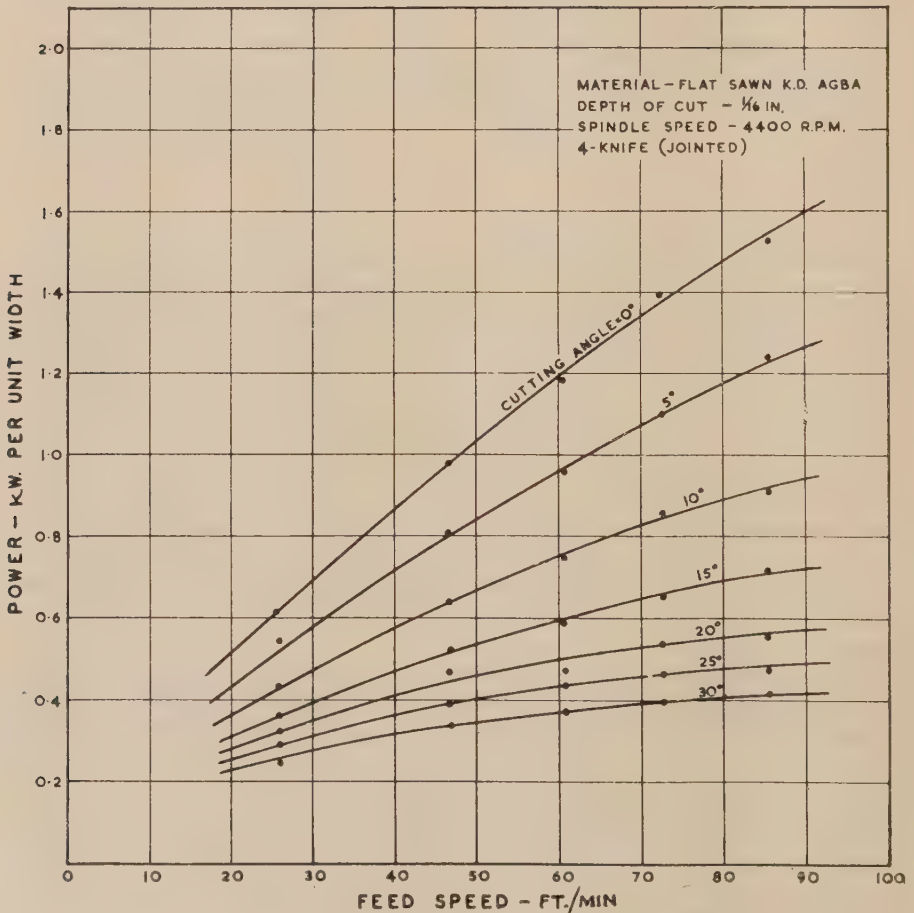


FIG. 2. RELATION OF POWER TO FEED SPEED IN PLANING

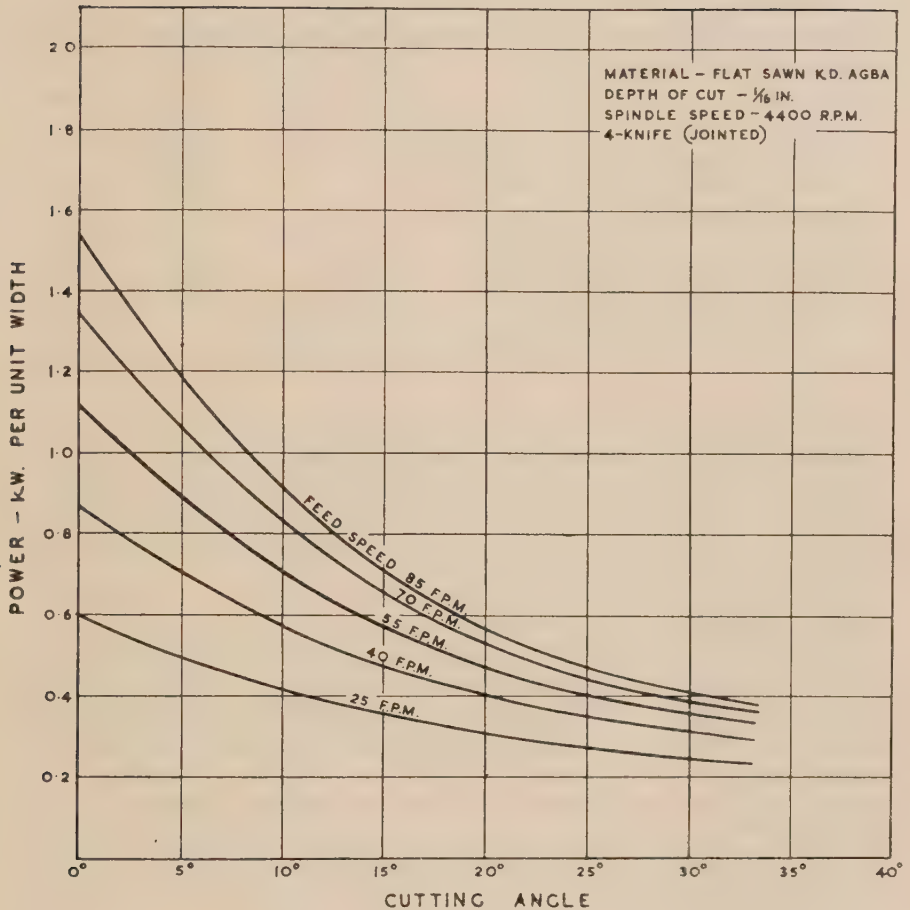


FIG. 3. RELATION OF POWER TO CUTTING ANGLE IN PLANING

of the chips removed and the cutting resistance for a specific wood depends not only on this thickness but also on the efficiency of chip ejection by the bit. With timbers containing resin, there is a tendency for it to act as a binder to the chips, which are not then readily ejected but may form a solid plug in the flutes. It may also be deposited on the tool clearance faces and cause overheating. It has been found that these troubles can be partly overcome by avoiding conditions under which small-size chips and dust are produced. The suitability of certain types of boring bit for particular classes of timber has been studied and information obtained on modifications required to the major cutting and clearance angles and the included angle of the wings. The importance of adequate clearance to the main cutting edges has been noted in these tests, for blunting appears to start at the clearance faces as shown by the appreciable rise in thrust. As blunting spreads to the actual edges, the torque also increases and the efficiency of cutting deteriorates, thus affecting the accuracy and the quality of the finish. A pilot test was made on the effect of bit size on the power demand, which was found to be approximately proportional to the square of the radius.

Woodworking Tests

Major scale woodworking and nailing tests were carried out and reports prepared on the following species:—

Kokrodua (<i>Afrormosia elata</i>)	kiln dried, from	the Gold Coast
African mahogany (<i>Khaya ivorensis</i>)	„ „	the Gold Coast
Brown sterculia (<i>Sterculia rhinopetala</i>)	„ „	Nigeria
Kurokai (<i>Protium decandrum</i>)	„ „	British Guiana
Wamara (<i>Swartzia leiocalycina</i>)	„ „	British Guiana
Binuang (<i>Octomeles sumatrana</i>)	„ „	North Borneo
Chilean pine (<i>Araucaria araucana</i>)	air dried, „	Chile
Sitka spruce (<i>Picea sitchensis</i>)	kiln dried, ex	Forestry Commission
(a) Inverliever, (b) Gravetye, (c) Drumtochty		
Norway spruce (<i>Picea abies</i>),	kiln dried, ex	Forestry Commission (Perthshire).

A comparison was made of the resistance to cutting and the blunting effect of Burma and Trinidad-grown teak (*Tectona grandis*).

Various sawing tests were carried out with the object of ascertaining suitable tooth shapes and pitch, speed or operating conditions in producing special articles from wood, or for cutting composite wood products and other materials including cork slab and compressed straw.

Advisory Work in Woodworking

Sawmilling and woodworking problems of considerable variety are the chief subjects on which advice has been sought. During the year increased interest has been shown in the design of furnaces and ancillary equipment for burning sawdust and other forms of wood waste, either for the purpose of disposal or for steam generation. Information has also been required on the briquetting of sawdust for fuel, the manufacture of charcoal, including kiln design, wood flour and chipboards.

The number of technical enquiries on Woodworking was 250, and advice was sought by 90 visitors.

COMPOSITE WOOD

Properties of Adhesives

The maintenance of the long-term durability tests upon adhesives for plywood manufacture and assembly work still absorbs much of the available time. Reports have been prepared upon the comparative behaviour of glues in lime and beech plywood (fifth year), the original Series II experiments on beech plywood (seven and a half years), and the ageing of gap- and close-contact joints (eighth year). Observations have continued upon the laminated beam and ply-clad frame units and routine examinations of the tests on the experimental motor torpedo boat at H.M.S. *Hornet* have been made.

The tests on plywood adhesives were extended to include exposures at the Ministry of Supply's Tropical Testing Establishment at Port Harcourt, Nigeria. The first three years of the experiment have now been completed and the results have been analyzed. Resins of phenol and resorcinol types when fully exposed to the tropical weather in beech plywood show negligible deterioration, as they do in temperate climates, but those of the less durable types of glue enable a comparison to be made between exposure in the tropics and in England. The life of beech plywood fully exposed to the weather is shown in Table 1.

Deterioration of similarly exposed gaboon plywood is not sufficiently advanced to enable a full comparison to be made between the two species beech and gaboon as testing media.

TABLE 1

Glue type	Time in years to reach failure as defined for the experiment	
	England	Nigeria
Melamine ..	— *	2
Fortified urea ..	4†	2
Urea	2	1½

* Although these samples have not in four years failed as defined for this experiment, they show considerable glue deterioration.

† Panels have been exposed in England a year longer than in Nigeria.

In addition to the full exposure to the weather, beech and gaboon plywood specimens are also stored under an open-sided bush hut at Port Harcourt (Plate 5). Under this exposure, deterioration of the phenol and resorcinol glues is again negligible and that of the melamine and fortified and normal urea glues only slight. A few of the test panels have been attacked by dry wood termites, the infestation having spread from the battens separating the panels.

Preserved Plywood

In the manufacture of plywood from veneers previously impregnated with preservative, a second drying can be avoided if the sheets can be treated in the wet state soon after leaving the peeler. A spraying plant has been built in which green veneers up to five feet in width are flooded on both sides with any selected liquid preservative, the penetration of which is effected by diffusion during close stacking for several days. The process is cleaner and quicker than passing the sheets through a dip-tank. The treated veneers can be mechanically dried in the same way as untreated stock, and none of the preservatives so far tested has had any ill effect on the metal parts of the dryer.

With such preserved veneers, two problems present themselves, viz.:—

- (1) Can the veneers be bonded satisfactorily?
- (2) Is the amount of preservative absorbed by the wood sufficient in quantity and adequately distributed to give a product that is resistant to fungal attack?

Tests have shown that with liquid phenolic resin glues setting at 100-120°C, reliable bonds can be obtained with at least some species. By the knife test, the bond quality is not quite so high as with normal veneers, but weathering tests of six months' duration have indicated that the bond, if initially of acceptable standard, is unlikely to deteriorate with time. On the other hand, a bond initially poor fails rapidly under exposure to weather. The second question arises because of the difficulty of measuring the amount of preservative absorbed

by the veneer during the diffusion process, as this quantity would normally be taken as the index of the efficacy of the treatment. The plywood is therefore being tested by direct exposure to rot-producing conditions. The associated work on the preservation of veneers is referred to on page 32.

Properties of Plywood and Veneered Products

Distortion of Plywood. Industrial enquiries show that the distortion of plywood is a recurring problem and a systematic study of the causes has begun. The variables being examined include the average moisture content of the veneers before pressing and the effect of variations in moisture content between and within individual veneers. Variables during the pressing process, such as the temperature of pressing and the pressure used, are also being examined. After manufacture the 5-ft. square, half-inch plywood test pieces are conditioned to 12 per cent moisture content, wetted to 15 per cent and then dried to 5 per cent moisture content. After each conditioning period, the panels are examined for distortion. A 5-ft. square hydraulic press is used, the panel being laid concave side downwards on the lower platen, which is then raised till the highest point on the distorted panel touches the upper platen. The gap between the two platens then gives a measure of the distortion.

So far, the results have been disappointing and often anomalous. Some earlier work, however, has indicated that plywood behaves erratically during the first cycle of moisture gain and loss, and settles down to repetitive movements only in the second or third cycle. The work is accordingly being continued until stable results obtain.

Surface Defects. When plywood is exposed to the weather without a protective coating, its surface becomes marred by a series of checks or fine splits running parallel to the grain of the surface veneer. The species of the top veneer of the plywood influences the degree of checking and fifty-nine timbers have now been examined with respect to this characteristic. The $\frac{3}{16}$ -in. thick plywood panels were exposed to the weather for two years, and after conditioning to 12 per cent moisture content, the amount of checking on each panel was assessed. Two grades of checking were admitted, viz. :—

Grade I: checks not readily visible to the naked eye.

Grade II: checks distinctly visible to the naked eye.

Some of the species falling into each grade are given in Table 2 and examples are shown in Plate 6.

TABLE 2

Grade I		Grade II	
Common name	Botanical name	Common name	Botanical name
Afara, white ..	<i>Terminalia superba</i>	Beech ..	<i>Fagus sylvatica</i>
Gaboon ..	<i>Aucoumea klaineana</i>	Birch, Canadian ..	<i>Betula lutea</i>
Guarea ..	<i>Guarea cedrata</i>	Guarea ..	<i>Guarea thompsonii</i>
Idigbo ..	<i>Terminalia ivorensis</i>	Obeche ..	<i>Triplochiton scleroxylon</i>
Nyankom ..	<i>Tarrietia utilis</i>	Pine, Scots ..	<i>Pinus sylvestris</i>
Seraya, red ..	<i>Shorea</i> spp.	Seraya, white ..	<i>Parashorea malaanonan</i>

Even if plywood is painted or protected by a plastic coating, the surface checking is not permanently inhibited, but the surfaced plywood remains unmarred longer than unprotected material of the same construction. The relative merits of a number of types of coating have been tested on beech plywood consisting of 3 x 0.125-inch veneers, and the life of the protected material when fully exposed to the weather is shown in Table 3.

TABLE 3
(Duration of test—36 months)

Surface treatment	Time after exposure when checking occurred (months)
None	5 to 7
Impregnated paper facings	8 to longer than 36
Paint	14
Painted plastic coating	Longer than 36

These times apply to the parts of the panels away from the edges, which in the experiment were unsealed. As this would not be the case in practice, checks originating at the edges have been disregarded in the assessment.

A cognate problem of great concern to the manufacturers of veneered products is the occurrence of defects in the surface of the finished article. In most cases the surfaces have a high gloss finish and blemishes, minute as they often are, become visible only after polishing. It has not been possible to undertake a systematic study, but examination of a number of defective panels received from industrial sources has indicated certain basic causes of the checking, which are here recorded because of their wide interest.

The two most common defects are small furrows and fine checks. The former, which appear to be an initial stage of surface checking, are in many instances present only in the surface of the finish and are removed by lightly sanding the polish.

On repolishing, a perfectly smooth finish is obtainable which remains only so long as no change in moisture content occurs; further drying produces furrows, while wetting gives rise to ridges. With surface checking, of course, no remedy, however temporary, is possible.

The prime cause of the defects can often be found in the base on which the decorative veneer is laid. The most common source of trouble is the presence of "lathe checks" in the outer veneers of the plywood or blockboard base. These "lathe checks" occur during the cutting of veneer and are present on the "loose" face,* being very pronounced on badly peeled material. Trouble arises when decorative veneer is laid on to plywood or blockboard where the "loose" side of the surface veneer is uppermost or alternatively where this veneer, though correctly laid, has been sanded so heavily as to expose the "lathe checks."

Conditions known to cause surface checking also arise when the decorative veneer itself has been heavily sanded. Here the veneer is too weak to withstand

* In veneer, the "tight side" is that which originally faced outwards in the log from which the veneer was peeled. The opposite side is the "loose face."

even the normal movement of the base material, and cracks occur *across* the grain. Sometimes the necessity for heavy sanding results from a thick glue spread and here additional checking may be caused by crazing of the adhesive itself.

In the cases considered here it has been assumed that the decorative veneer is laid with its grain at right angles to that of the adjacent veneer of the base material; if the two grains are parallel (a condition to be avoided if possible) the effect is very much worse.

Temperature Penetration and Moisture Migration in Plywood

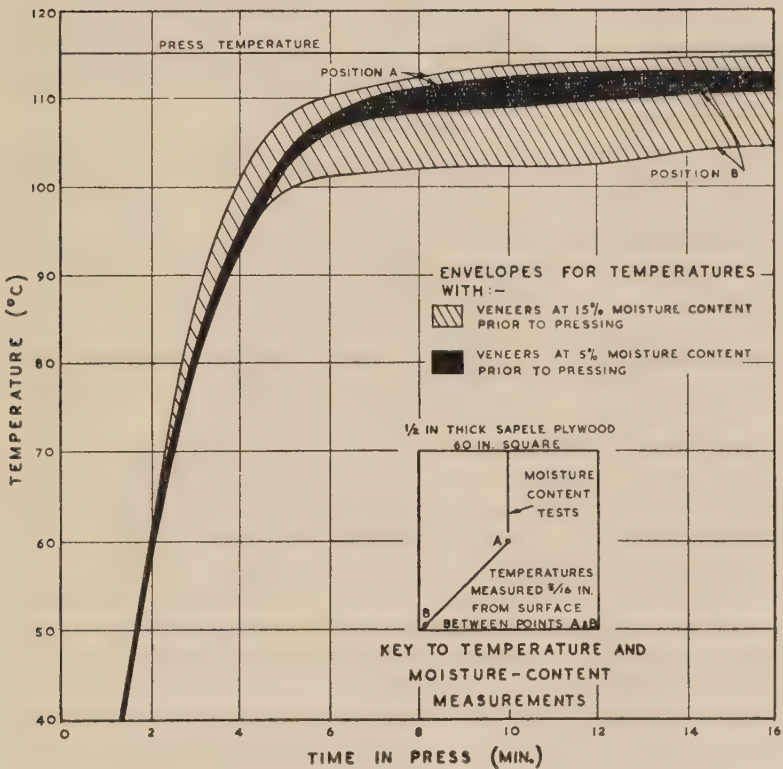
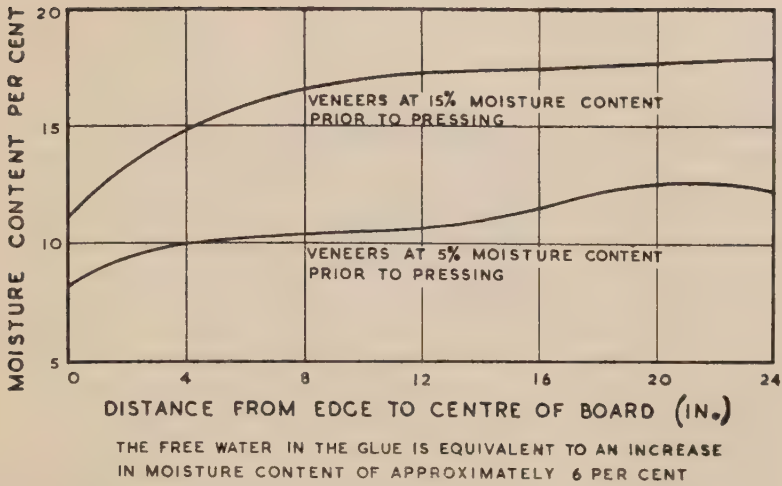
In the hot pressing of plywood, the rate at which the heat from the platens moves through the board is of great importance in determining the time required to cure the adhesive. The subject of temperature penetration has very rightly received wide attention; many excellent papers setting out the basic theory have been published and numerous graphs are available to help the practical man. Sometimes factors have to be applied to the times indicated by these graphs to allow for conditions in a specific case, and for the sake of safety, the factor is often made larger than is really necessary. This unduly prolongs the curing time and thus reduces the output of a press. As an example of particular conditions may be cited the lower rate of temperature rise round the edges than at the centre of a board following the conversion of the moisture in the wood to steam and its ready escape to the atmosphere. From the centre of a board, the escape of steam is less easy and its formation is often prevented at the expense of an internal pressure. Observed values for temperature rise within a 5-ft. square plywood panel during heating and of the moisture content distribution after the curing period are shown in Fig. 4.

Data of this kind are being systematically collected for different board thicknesses, veneer species, types of glue, and initial moisture content of veneer and pressing temperatures with the object of establishing more reliable factors for these edge effects, work that will probably lead to a reduction in the pressing times now commonly allowed in plywood manufacture.

The migration of moisture at platen temperatures around 145°C also appears to be closely related to the phenomenon of blistering. This has been found to occur in veneer packs uniformly dried to a moisture content of as low as 8 per cent. In a veneer pack the rate of warming usually slows considerably after 110°C when moisture begins to boil off, but in certain instances the observed rise was abnormally rapid, indicating that moisture was trapped in the veneers. This trapped moisture can exert a vapour pressure at the end of the warming period large enough to rupture the fibres when the press is opened. The effect seems to be confined to a few species and may also be associated with abnormally high compression in the press owing to the presence of "brittleheart." It is greater at high moisture contents, but not entirely confined to the wet patches which are sometimes found in recently dried veneer.

Moisture Content Determination

For the efficient control of a veneer dryer it is essential to have a rapid means of determining the moisture content of the dried veneer as it leaves the machine. The two devices which have been developed for this purpose, the "Naiad" (Annual Report 1950, p. 31) and the "Platen Oven" (Annual Report 1952, p. 23),



use a 6-in. square of veneer, but the cutting of the test pieces introduces delays and the sheet from which they are taken is wasted. A non-destructive method of determining the moisture content would be an obvious advantage. Electrical moisture meters have been used on the veneer as it comes from the machine, but systematic tests have shown that those of the resistance type, in which pins are inserted on one side of the veneer, give erroneous readings because of the large moisture gradient through the thickness of the veneer. A capacity type of instrument was then examined, to find whether, if the electrodes were put on either side of the veneer, the meter would measure the total amount of moisture present. Extensive tests showed, however, that at one instrument setting, the moisture content of the veneer could vary between 8 per cent and 15 per cent, which was more than could be accounted for by species correction and local variability of the timber. The possibility that other types of moisture meter may be more suitable for use with freshly dried veneer is being investigated.

Trials of Timbers for Plywood Manufacture

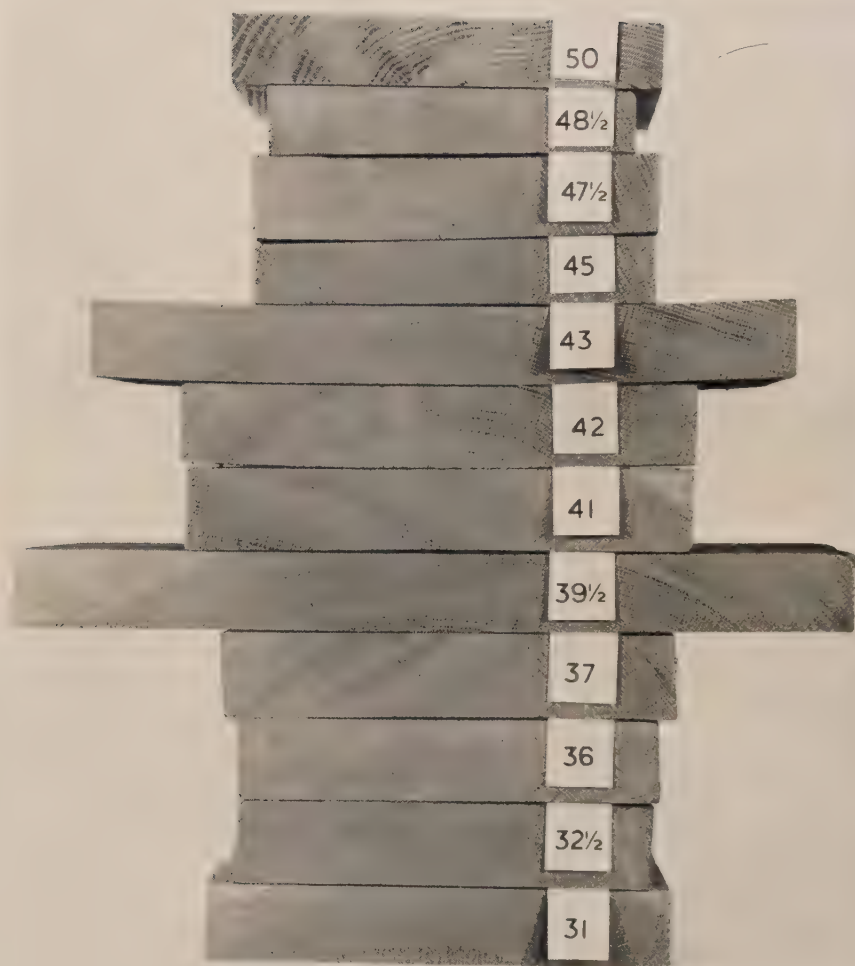
During the year, twelve species have been tried on a large or small scale for suitability for plywood manufacture, bringing the total of the timbers tested in the 5-ft. plant to forty-seven.

Amongst these timbers was home-grown poplar, the veneer from which often has a woolly appearance owing to the lifting or even complete removal of groups of fibres. Tests were made to see how far the surface condition of the veneer could be influenced by adjustments of the knife and nosebar and by treatment of the billets; attempts were also made to prevent accumulation of masses of fibres on the knife and nosebar by means of an air jet and by brushing the surface of the billet.

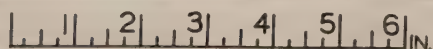
Although most tests gave negative results, the work confirmed that smooth veneer is obtainable from poplar if it is peeled from cold billets which are thoroughly wet. This requires qualification, for even in billets such as these, extremely woolly veneer was found to occur in regions. Observations of distortion and measurements of shrinkage of this veneer during drying led to the conclusion that extensive tension wood areas were present, which was later confirmed by microscopic examination and staining tests. While it would not be safe to conclude that tension wood is the sole cause of "woolliness" in poplar, its presence accounted for most of the woolly veneer obtained in these tests.

Study of Plant and Machinery

Spooling. The lathe for the production of veneer for plywood manufacture is capable of high-speed operation providing means of handling the output are available. Since the Laboratory's plant was first described in the Report for 1939-47 (pp. 65-8), considerable attention has been given to means of veneer spooling, and recently peak speeds of 750 to 800 ft./min have been achieved. The first essential is a well made spool, preferably with ball-bearing ends, running in V-blocks or similar housing accurately lined up with the peeler spindles. At such speeds, power driving is advisable, and synchronization of spool and lathe speed is necessary. A series-wound d.c. motor with a resistance regulator working through a V-belt reduction gear has proved satisfactory and virtually self-controlling. The motor is rated at 0.6 h.p., which is rather low for accelerating spools 5-ft. long and 18-in. to 24-in. diameter. Veneer down to 0.03-in. thickness has been wound without breakage through snatch or excessive tension.



JAPANESE OAK : DENSITY (lb/c.ft)



Selection of samples from a parcel of prime Japanese Oak showing variation in density owing to varying proportions of dense fibrous tissue. The density and strength of the wood can be estimated roughly by careful inspection of the clean-cut end-grain.

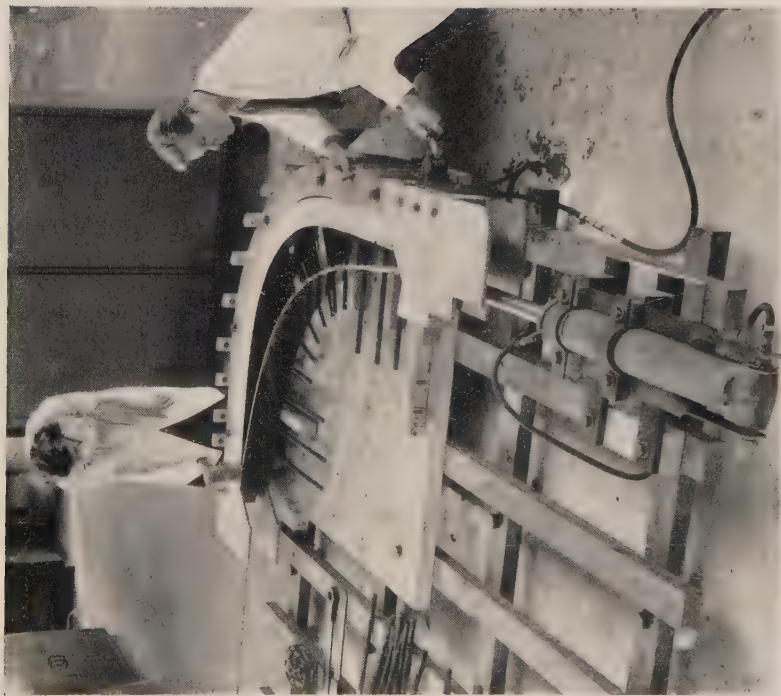
VARIATION IN DENSITY OF JAPANESE OAK

PLATE 1

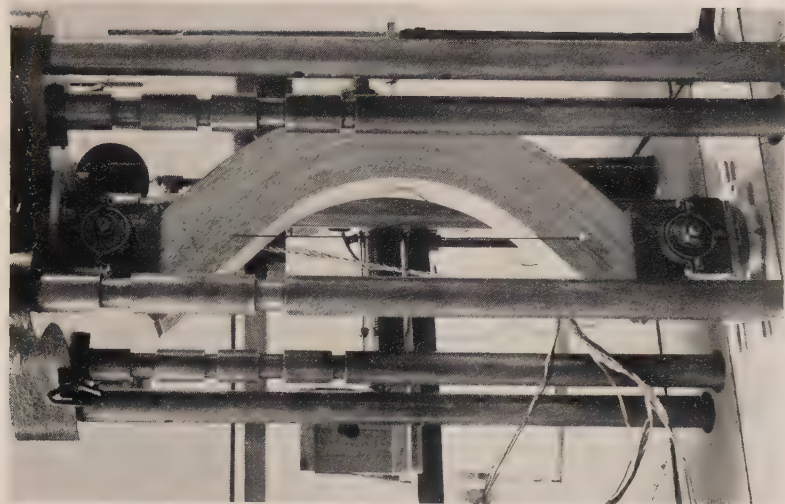


SECTIONS OF BOARDS OF ABURA (LEFT) AND OBECHÉ (RIGHT), KILN-DRIED TO
NORMAL SCHEDULES (N) AND IN SUPERHEATED STEAM (S)

PLATE 2



(A) BENDING LAMINAE TO SHAPE BY THE
APPLICATION OF END PRESSURE



(B) A LAMINATED BEND UNDERGOING
TEST

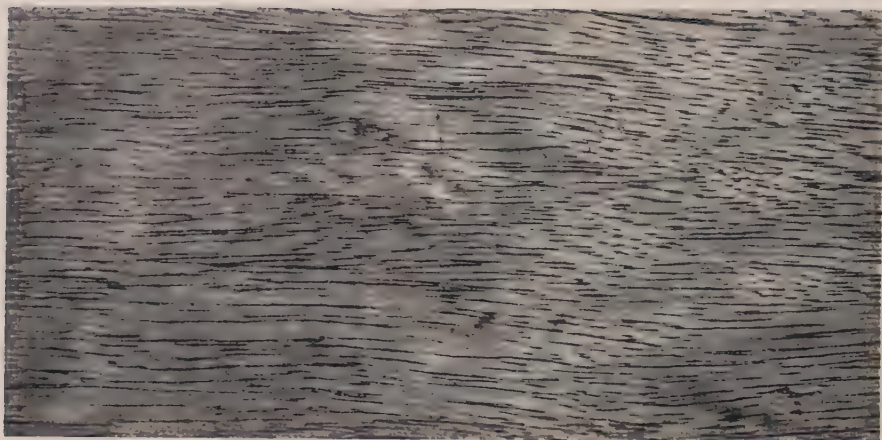


KILN OPERATORS' COURSE IN PROGRESS (SEE HISTORICAL NOTE IN TEXT)

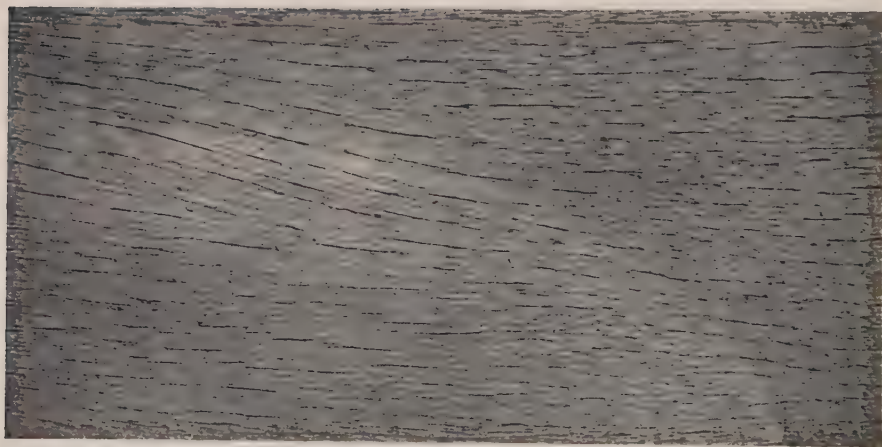


Panels stored in an open-sided shed or "bush hut" at the Tropical Testing Establishment,
Port Harcourt, Nigeria.

LONG-TERM DURABILITY TESTS ON PLYWOOD ADHESIVES



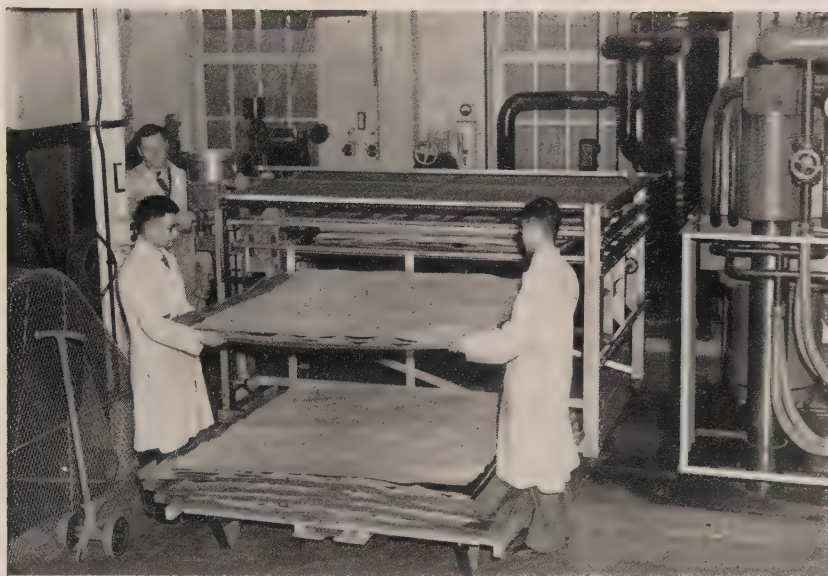
Grade I. Afara



Grade II. Guarea

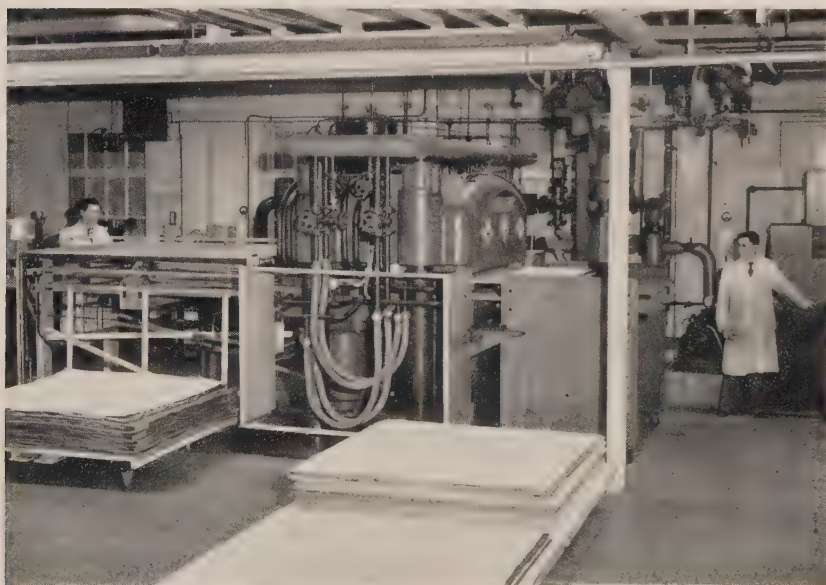
THE SURFACE-CHECKING OF PLYWOOD EXPOSED TO WEATHER

PLATE 6



(a) Charging the Loader

The caul carrying each plywood lay-up is lifted at its front end by a chain-driven roller-bar which stops automatically opposite the appropriate opening in the loader, into which the caul is then pushed by the operators.



(b) Charging the Press

When the pressing of the previous batch of boards is completed and the press is opened, chain-driven fingers in the loader push in the new charge, the cauls of which push out those carrying the boards cured in the previous cycle. The detachable truck at the discharge side of the press carries the newly-pressed boards to the stack.

PLYWOOD PRESS-LOADING GEAR

PLATE 7



The strip of wood is clamped vertically, with a weight at its lower end. The above double exposure photograph shows the strip in its vertical rest position, and also at the extremity of its swing when oscillating as a pendulum. The elasticity modulus is calculated from the frequency of vibration and dimensions of the strip; the deflection curve of the vibrating strip is obtained by measuring the distance between the stationary and the vibrating strip at a number of points along its length.

DETERMINATION OF MODULUS OF ELASTICITY

PLATE 8

As an alternative, a differential unit has recently been installed fitted with a 2-h.p. a.c. motor and remote control of the braking gear. This is now under-going trial.

Veneer Clipping. The Annual Report for 1952 (p. 23) stated that a simple form of pre-selector clipper had been built at the Laboratory for the study of the process. Some observations on the overall accuracy of the gear are recorded in Table 4. As they stand, the figures are not particularly good, but the various causes of the variations have been elucidated, and a much better instrument could now be made without unduly complicating the existing mechanism. Considerable interest has been taken in the plant by industrial concerns. Experience in the Laboratory's peeling trials over twelve months has shown that the pre-selector clipper considerably speeds up the conversion of spooled veneer to sized sheets, reduces the fatigue of the work, and improves on the accuracy of dimensions.

Veneer Drying. The study of veneer drying by a contact type of dryer has continued and the most efficient method of operating has been determined. Tests have shown that most of the drying takes place during the "dwell" period when the heated plates are in contact with the veneer. For fastest drying, therefore, the dwell period should be as long as possible and the open or "breather" period as short as possible. The drying rate of veneers is greater at higher temperatures and the machine has been modified so that the platen temperature can be raised to 170°C. Limited tests have shown that the quality of the dried veneer has not fallen with the increase in operating temperature. A study of heat quantities showed the need for improvement in efficiency and the machine has been totally enclosed and the air flow controlled.

Although the platen type of dryer is not considered to be well suited for the purpose, veneer has been dried in a continuous length direct from the spool. The quality of the product was not so good as when dried sheet by sheet, but further trials will be made before the tests are abandoned.

Pressing. The 1952 Annual Report (p. 24) spoke of press-loading arrangements that cut "dead time" (i.e. the period over which the press does no useful work) to 45 seconds per cycle. The press loader has been further improved to reduce the catching-up of cockled veneers as they move into the press daylights, and a simple lift has been fitted that greatly facilitates the transfer of cauls carrying the plywood lay-up from the pallet to the loader (Plate 7). It should be mentioned that although the Laboratory's press has only two daylights, the loader has been designed to be applicable to multi-daylight presses.

General

The Adhesive Makers' Panel and the Plywood Research Panel continue to hold meetings periodically, and their value as a means of liaison between the Laboratory and industry is now firmly established. The former dates from 1945 and the latter from 1949.

Advisory Work in Composite Wood

During 1953, 450 industrial enquiries were received.

WOOD PRESERVATION

Testing of Wood Preservatives

The standard scheme of testing wood preservatives has now been in progress for about 23 years and although none of the tests on individual preservatives

TABLE 4
Pre-selector Clipper

Analysis of numbers of sheets falling within the limit of ± 0.25 and ± 0.5 in. of the average widths for various conveyor speeds, veneer thicknesses and nominal widths

Automatic clipping of whole- and half-width veneers

Veneer thickness (in.)	Conveyor speed (ft./min.)	Wholes—Nominal width 66-in.				Halves—Nominal width 33-in.			
		Av. width (in.)	No. of samples	No. within ± 0.25 -in.	No. within ± 0.5 -in.	Av. width (in.)	No. of samples	No. within ± 0.25 in.	No. within ± 0.5 in.
.127	45	65.9	16	6	10	32.8	19	6	12
.064	30	66.0	16	7	14	33.0	18	12	17
"	45	65.8	18	14	18	33.0	21	8	20
"	60	65.7	32	23	27	---	---	---	---

Pre-selection of widths by manual operation of buttons
Veneer 0.064-in. thick. Conveyor speed 20 ft./min.

Nominal width (in.)	Actual width (in.)	No. of samples	No. within ± 0.25 -in.	No. within ± 0.5 -in.
6.1	6.1	54	43	52
12.2	12.3	58	41	56
18.3	18.4	57	37	54

is yet completed, a good deal of information on the performance of all the more important preservatives has been obtained. The results of the tests to date have been included in an interim report.

Transmission Poles

As mentioned in last year's Report (p. 27), some creosoted Baltic redwood poles tend to bleed badly when exposed to the sun. This trouble occurs with poles of Swedish and Finnish origin but not with those from Norway. This problem has been aggravated by the increased gross absorptions now being used.

During the year experimental treatments have been carried out to try to find a method of treating the poles so that subsequent bleeding does not occur. It was found that Norwegian poles could be creosoted so as to penetrate the sapwood completely with gross absorptions considerably above those now being used without bleeding taking place. These poles have remained perfectly dry throughout the summer. On the other hand, Swedish poles even when treated by the normal gross absorptions have bled badly and have remained in a very dirty condition.

It was clear that the most likely solution would be to keep the poles at a higher temperature during the treatment than is usual in commercial procedure. Merely increasing the temperature of the creosote itself did not have the desired effect. Various methods of heating the poles were tried and the only completely satisfactory one was by steaming. Poles which had been steamed were clean when removed from the cylinder and showed no signs of bleeding throughout the summer when exposed to the sun. With some poles a final steaming of about one hour was sufficient but with others a clean pole could be obtained only by steaming both before and after creosoting.

Pressure Impregnation of Timber

Douglas fir, which is one of the main structural timbers used in this country, is being supplemented with western hemlock. There has been practically no experience of the preservative treatment of this timber in the United Kingdom and to obtain information a number of experimental pressure treatments have been carried out on sleepers and bridge timbers.

Hemlock appears to be considerably easier to impregnate than the normal run of imported Douglas fir but is very variable. For this reason it has been found that in general it is advisable to incise it and creosote it by the empty cell process. Some consignments received at the Laboratory were found to contain an appreciable amount of a species of fir (i.e. *Abies* sp. probably *Abies grandis*) which was much more absorbent than the hemlock. It is not easy to distinguish this fir from the hemlock.

It is believed that western hemlock may in the future have to be used on an increased scale for sleepers in this country, and trials are now being carried out by British Railways. The Laboratory has been asked to co-operate in this investigation.

Sleeper Investigations

The service trials have been in progress since 1935 and are now nearing completion, sleepers being gradually taken out of the line during the course of normal track re-laying. Originally they were distributed over 12 sites and have

now been replaced at 9 of them. The sleepers at 3 sites have been taken out this year and have been inspected. It appears at present that in fast main lines generally the mechanical degrade is a much more common cause of deterioration than fungal decay.

Treatment of Plywood

Work has continued on the preservative treatment of veneers. It has been found that it is possible to treat dry veneers satisfactorily even those of timbers that are extremely resistant to impregnation in the solid. A satisfactory treatment can be obtained with a cold steeping, open tank, or a short pressure treatment.

There are several ways of treating green veneers. One which has been used in Australia consists of dipping the veneers in a concentrated solution of a water-soluble preservative and then close stacking the veneers for a few days to allow the salts to diffuse. As it would be very much quicker, it was considered worthwhile to look into the possibility of treating them by pressure or the open tank process, although these are not normally used for green material in bulk. The difficulty in this work, however, has been (as mentioned on page 23), to find a satisfactory way of assessing the effectiveness of these various treatments. The usual laboratory methods for doing this do not seem to give a reliable indication of the effectiveness of the treatments so that it has been decided to base the assessment of the various treatments on the results of an exposure test out-of-doors of plywood made up from veneers treated in different ways.

Advisory Work in Wood Preservation

Advisory work by letter, telephone and visits has remained at about the same level as recent years. The number of enquiries dealt with by letter in 1953 was 488.

MYCOLOGY

Collections

The catalogue of the collection of wood-rotting fungi has been revised and sent to other institutes. Further species have been added to the collection, which has been sub-cultured twice. One hundred and twenty-six cultures have been supplied on request to research institutes and firms. Twenty-eight cultures and many fructifications were sent in to the Laboratory for identification.

Physiology of Wood-rotting Fungi

Tests on the viability of fungi in air-dry wood continue and a progress report on the results with *Merulius lacrymans* and *Poria incrassata* has been prepared.

Dr. Birkinshaw, at the London School of Hygiene and Tropical Medicine, has discovered in *Daedalea juniperina* an interesting compound of a type not previously known as a metabolic product of fungi.

Attempts are still being made to ascertain how many of the fungi isolated from wood showing "soft rot" are able to decompose wood. Though many of the fungi isolated may be secondary colonisers of wood which is already decayed, it is possible that difficulties experienced in obtaining satisfactory growth of these fungi on wood in culture arise because the methods of culture so far used are suitable for only a few of the species involved.

Attack of beech by a species of *Stysanus*, a member of the Fungi Imperfecti, has proved of considerable interest as the hyphae of this fungi bind the decayed wood fibres together and so permit of more reliable observations on severely decayed wood than have previously been possible with other species.

Extensive soft rot has been observed in a number of instances where wood was exposed under natural conditions. In particular decay was observed at a depth of $1\frac{1}{2}$ in. in a Scots pine pile from Portsmouth harbour and throughout a Corsican pine telegraph pole 8 in. in diameter.

Confirmation has been obtained that the rate of attack of beech by *Chaetomium globosum* in pure culture is proportional to the amounts of mineral nutrients available to the fungus. By increasing the amounts of inorganic salts in agar medium, a maximum weight loss of 36.4 per cent in 6 weeks has been obtained on 0.5 cm. thick beech exposed in contact with the medium. The amount of decay *in vitro* appears to be correlated with the density of fruit body formation. This is in marked contrast to decay under natural conditions in which fruit body formation is unusual on any timber showing soft rot.

Breakdown of Timber in Water-cooling Towers

Co-operation with the British Electricity Authority continues. In one of the towers inspected, decay caused by Basidiomycetes was present in many of the structural timbers which were only wetted intermittently; this was found in addition to the usual soft rot on the filling timbers.

Soft rot has been observed in slats from a tower at Gibraltar in which only sea water is circulated.

Bacterial attack has been found on Californian redwood filling timbers from a cooling tower at Bulawayo, Southern Rhodesia. The gross appearance of these timbers was similar to that of wood attacked by soft rot. Bacteria have frequently been observed together with fungi in samples of wood from this country and it is probable that bacteria normally carry out the final stages of decomposition of the wood. At Bulawayo the operating temperature may be higher than is usual in the United Kingdom and sufficiently high to discourage fungal growth.

Laboratory Tests on Wood Preservatives

Standard wood block tests on 5 proprietary preservatives and agar tests on 2 products have been completed.

Tests on the effectiveness of 7 well known proprietary products, used for surface application, have shown that whereas most of them effectively protect the wood if the test pieces are immersed for 10 minutes, some of them fail to do so when the period of immersion is only 10 seconds, a treatment considered roughly comparable to one brush-applied coat. This implies that in order to get a satisfactory degree of protection by surface application of these products, at least two brush treatments should be given.

Laboratory Tests on Durability of Timber and Other Materials

Laboratory tests on the decay resistance of the following timbers have been completed:—

Bahamas pine, wamara (sapwood), evino, laburnum, sepetir.

A paper summarizing the results of tests on the effect of size on the rate of decay of samples has been published.

The resistance to moulds of various types of gasket has been tested on behalf of the Minister of Supply, and further samples of fire hose from the Fire Research Organisation have been received for test against *Chaetomium* under standardized conditions.

Dry Rot Investigations

In co-operation with Building Research Station, laboratory screening tests of materials for sterilizing masonry infected with *Merulius lacrymans* are being continued.

Treated mortar blocks have been exposed to cultures of *Merulius lacrymans* in Kollé flasks, and the reactions of the fungus and the extent of overgrowth of the blocks during a four-week incubation period observed. Following the discovery that *Merulius* was unable to grow over blocks cast from a mix of lime mortar in use on the premises, the tests have been extended to include different mortar mixes as well as the effectiveness of fungicidal renderings and solutions. Overgrowth of the test blocks was effectively prevented by ethyl mercury phosphate and by calcium pentachlorophenate incorporated in a polyvinyl emulsion paint.

After the flooding that occurred earlier in the year in many East Coast towns, enquiries were received as to the effect of immersion in sea water on the liability of wood to attack by the dry rot fungus. Tests were carried out with test pieces of wood impregnated with sea water, but results were inconclusive. The sea water did not appear to have any fungicidal effect but under the very humid conditions in the flasks the blocks became saturated with water and the high moisture content of the wood inhibited attack. On the other hand, under practical conditions, the hygroscopicity of wood containing sea water might under slightly damp conditions raise its moisture content sufficiently to permit attack. Further tests using a different technique are planned.

Decay of Timber in Boats

An inspection of H.M.S. *Victory* has been carried out. A favourable impression was gained of the general condition of her oak timbers, the only active decay noted being on softwood beams which were installed during fairly recent repairs. However, in spite of improved ventilation in the holds of the vessel, the moisture content of many of the old timbers is still high enough for fungal decay to proceed. It is thought that the practice of hosing down the decks contributes to this dampness.

It has been arranged that moisture-content determinations shall be made periodically on timbers in different parts of the vessel so that the progressive drying out of the hull can be followed.

In order to gain experience of a wider range of craft a number of boats on the Thames have been inspected.

The bulletin on decay in boats has been prepared and is now being printed.

Sap-stain Investigations

Sapwood disc tests carried out on organic tin compounds have shown that some of them are highly toxic to sap-staining fungi. In this test either unseasoned sapwood discs of Scots pine or oven-dried discs impregnated with 1 per cent malt solution are treated with a series of dilutions of the sap-stain preventative,

then, together with untreated control discs, are sprayed with a suspension of spores of staining fungi before being incubated for four weeks. The degree of staining of the wood on conclusion of the test permits an estimate to be made of the efficacy of the treating material.

The identity of a number of cultures of fungi isolated at the Laboratory from stained tropical hardwoods has been determined by Dr. Zambettakis, of the Muséum National d'Histoire Naturelle, Paris. The identifications show that the fungus most often isolated is *Lasiodiplodia theobromae*, Gr. et M., and that *Diplodia natalensis*, Evans, occurs much less frequently.

Sometimes stain continues to spread in boards of ramin during the early stages of kiln drying when the temperature is not high enough to arrest the growth of the staining fungus, and it is recommended that a short period at high temperature in a saturated atmosphere should be given at the beginning of the run. In order to determine temperatures lethal to *L. theobromae* in wood a series of experiments has been carried out using one-inch cubes infected with the fungus naturally or in pure culture. The cubes were sealed in toy rubber balloons and heated for varying periods by submersion in hot water. The effect of the heat treatment on the fungus was assessed by determining whether or not the fungus would grow from wood chips taken from the centre of the block and incubated on malt agar.

Prevention of Deterioration in Logs of Perishable Species

Delay in the conversion of logs of species susceptible to decay, such as beech and sycamore, frequently results in serious deterioration owing to incipient decay (dote), especially during the warmer months of the year.

A field experiment has been started to assess the value of antiseptic spraying and end coating of the logs. Beech logs brought to the Laboratory soon after felling in March were cross-cut into 6-ft. lengths and sprayed immediately afterwards with various fungicides, including creosote and 5 per cent sodium pentachlorophenate. The ends of half the logs were in addition covered with a bituminous end coating. The treated logs, together with the untreated controls, have been laid in the grass under a hedge. Sample groups of logs were sawn up after 3 and 6 months' exposure and the extent of dote assessed. Further batches will be converted after longer intervals.

After 6 months there was a noticeable difference between the condition of the untreated logs and of those that had received some preservative treatment. Incipient decay had spread throughout some of the untreated logs and fruiting bodies of wood-rotting fungi (mainly *Stereum purpureum*) were appearing on the ends of the logs. Little decay was observed in logs that had been sprayed with creosote or 5 per cent sodium pentachlorophenate and whose ends had in addition been coated with a bituminous paint.

Cultures were prepared from decayed portions of the untreated logs and *Hypoxylon coccineum* was isolated from those areas in which dark-coloured zone lines were visible.

Advisory Work in Mycology

As in previous years most of the enquiries were concerned with the recognition, treatment and prevention of fungal decay of woodwork in buildings. Many letters were received about the risk of dry rot following the flooding of property in East Coast towns affected by the floods early in the year.

Many enquiries about rot in boats have again been received, and a case of extensive decay in the woodwork of a refrigerated hold of a recently built ship was reported.

Staining and mould on imported hardwoods have been the subject of many enquiries and complaints about mildew on susceptible timbers such as obeche were unusually frequent during the autumn, many of them being no doubt the result of the mild, humid weather then prevailing.

Among enquiries of interest the following may be noted:—decay in woodwork of chicken egg incubators while in use, the rotting of staves of fermentation vats, mould on willow for artificial limbs and for cricket bats, and mildew on a consignment of bamboo back-scratchers imported from China.

Once again the number of enquiries received shows an increase over the previous year and 1,140 were dealt with by letter. A number of inspections was carried out but it has not been possible to meet all the requests for inspections of property attacked by dry rot.

ENTOMOLOGY

General

Research has been concerned chiefly with the bionomics and control of the common furniture beetle and the house longhorn beetle but further attention has been given to the development of improved techniques for laboratory tests of materials for the prevention or eradication of infestation.

The following is a more detailed summary of the work carried out during the period under review:—

Lyctus Powder-post Beetles

Starch Depletion in Kiln-dried and Air-dried Oak. The comparative susceptibility to *Lyctus* attack of air- and kiln-dried hardwoods, as determined by the effect of the method of seasoning on starch content of the sapwood, has recently been the subject of correspondence in the timber trade press. Accurate data on the problem are lacking and a final answer must await controlled tests with different timbers of known starch content. In the meantime, a small-scale investigation has been started at the Laboratory with freshly sawn 1-in. oak boards, of which half were kiln-dried and half left in stick for air seasoning. It is of interest to note that considerable depletion of starch took place during kiln drying—probably during the initial warming up of the kiln—which may be compared to the depletion which usually occurs during the slower processes of air seasoning. These preliminary results are supported by numerous observations on starch content before and after kiln seasoning of oak and other hardwoods in the course of work at the Laboratory on *Lyctus* and its control.

Studies of Infestation in Oak Block Flooring. Damage by *Lyctus* in new hardwood flooring continues to cause concern to contractors, architects, builders and others. Although it is usually possible from a knowledge of the habits of the insect to indicate the origin of attack and assess the risk of spread of infestation, more definite data based on practical tests are desirable. With this object in view, a series of test panels has been prepared, incorporating kiln-dried oak floor boards laid in accordance with normal practice. In some panels, a number of the blocks was exposed to attack at various intervals before laying. Progress of damage, emergence of beetles and spread of infestation from attacked

to sound blocks are being studied. Other panels were exposed to infestation at various stages of preparation, e.g. after embedding of the blocks, after sanding and oiling or after polishing, with the object of determining the degree of protection afforded to finished and semi-finished flooring. It is intended to extend this type of experiment to include strip flooring of the suspended type. The technique of test will later be used to assess the value of insecticidal dips for application to flooring before laying and also to determine the value of surface application of insecticides for eradicating existing infestation.

Prevention of Attack by Insecticide Treatment of Sawn Logs. In continuation of previous work on the prevention of infestation by *Lyctus* in stacks of English oak boards sawn through and through, superficial examination has been carried out of timber treated in May, 1952, with benzene hexachloride applied by spray or dip as a water-dispersible powder or oil emulsion at concentrations of 0.5 and 0.325 per cent of the gamma isomer. Preliminary results in September, 1953, indicate that complete protection was afforded by all treatments at the higher concentration; slight attack and emergence were recorded in a single board treated by spray at the lower concentration of the water-dispersible powder: emergence has taken place from the untreated controls. Detailed examination of individual boards after planing is necessary before the true efficacy of the treatment can be determined.

A revised edition of Forest Products Research Leaflet No. 43 on spray treatments for sawn logs was issued during the year.

The Common Furniture Beetle, Anobium punctatum

The study of material exposed for egg-laying in previous years has been continued and concentrated on the examination of sound and decayed heartwood. In the case of both fresh and old heartwood of Scots pine decayed by a brown rot, larvae have been found still feeding and tunnelling nearly three years after egg laying, but none in the controls. Larvae have survived in heartwood more severely decayed than the sapwood previously examined. Attack was found, however, to have died out in both sound and decayed oak heartwood after a similar period of time. Some evidence has also been obtained that although a preference is apparently shown for egg-laying on sound Scots pine sapwood rather than the heartwood, where decay is present, such a choice may not be exercised. Some confirmation from experiment has thus been obtained of observations made in the course of advisory work that attack may spread into heartwood in the presence of decay thus rendering this insect of greater structural significance in certain circumstances than has hitherto been realized ⁽¹⁾.

The use of an artificial surface for egg-laying studies, using muslin, as outlined in the Report for 1950 (p. 52), and fully described elsewhere ⁽²⁾, has been adopted at the Laboratory as standard practice in general biological studies where it is desired to obtain egg-laying in certain positions. It is less suitable for some investigations into the exercise of choice of material for egg-laying, where natural surfaces are to be preferred. The muslin technique provides a uniform surface on all types and species of wood, whether sound or decayed, fast or slow grown, rough or smooth sawn, and thus ensures more uniform egg-laying than would

(1) BLETCHLY, J. D. The Influence of Decay in Timber on Susceptibility to Attack by the Common Furniture Beetle, *Anobium punctatum* De Ge. *Ann. appl. Biol.*, 1953, **40** (1), 218-221.

(2) BLETCHLY, J. D. A Summary of Some Recent Work on the Factors Affecting Egg-laying and Hatching in *Anobium punctatum* De Ge. (Coleoptera Anobiidae). *Trans. IXth int. Congr. Ent.*, 1952, **1**, 728-734.

otherwise be the case owing to the varying suitability of natural surfaces. Moreover, this method facilitates egg counts. Earlier work has shown that equally good egg-laying can be obtained on suitable natural surfaces, but this method has been found less satisfactory for the reasons given above.

Advantage has been taken of the receipt of a few matched samples of New Zealand white pine (*Podocarpus dacrydioides*) sent by the Division of Forest Products, C.S.I.R.O., Australia, to examine the suitability of this material for breeding purposes, and to compare the results with those obtained in recent Australian work ⁽¹⁾. The number of eggs laid on the end grain surfaces without muslin has been similar to that on other species exposed in the same way with or without muslin. Preliminary results of larval transfer experiments indicate that the rate of gain in larval weight is similar to that in sound sapwood of Corsican and Scots pine.

Some experimental verification of the apparent susceptibility of birch plywood made up with blood and casein glues has been obtained during the year, by the emergence during spring 1953 of beetles from Finnish birch plywood of pre-war origin made up with blood glue and exposed for egg laying in the summer of 1950 and since kept at 22°C and 86 per cent relative humidity: some of this material was almost completely disintegrated. No emergence occurred from controls of solid birch which, however, were not of the same origin and there were no similar external signs of disintegration.

A comprehensive investigation has been started into the susceptibility of birch plywood made up from veneers cut from different zones of material obtained from logs steamed before peeling or peeled cold. Samples of 3-ply made up with three glues from 1/16-in. veneers, taken from zones at intervals of 1 in. from the periphery of the log, have been exposed for egg-laying.

For comparison with Corsican pine material treated with various extractives and exposed for egg-laying in 1952, a further experiment has been started with freshly seasoned English oak sapwood and heartwood using a wider range of extractives to remove fats, starch, sugars and tannins in various combinations.

Data on the incubation period of *Anobium* eggs under laboratory conditions have been supplemented.

The House Longhorn Beetle, Hylotrupes bajulus

Distribution in the United Kingdom. During the year, several cases of attack have been reported from widely separated areas, but except in some districts of Surrey only isolated occurrences have been concerned and in most, inspections of buildings or examinations of samples sent to the Laboratory have indicated that attack was no longer active but had been extinct probably for many years. In one Surrey town where the first case of infestation came to light in 1952, a survey of a Council Estate, comprising 66 houses, was carried out by the Local Government Authority; 22 houses were found to be actively infested. An inspection was subsequently made by the Laboratory whose advice on treatment was sought. With the co-operation of the Local Authority and the servicing firm responsible for the treatment, arrangements have been made for observations on the remedial measures being applied in order to attempt to assess their efficacy.

⁽¹⁾ ROSEL, A. The Breeding of *Anobium*. Preliminary Observations on Oviposition. Div. For. Prod., C.S.I.R.O. Austr., Proj., P. 19, Sub-proj. P. 19/2. Prog. Rep. No. 1 (1952).

An analysis has been made of all cases of attack by the house longhorn beetle which have come to the notice of the Laboratory since 1934 and a general account of the distribution of the insect in the United Kingdom including a discussion of the possibility of spread of infestation in relation to the quality and dimensions of softwood roofing timbers in modern buildings has been published ⁽¹⁾. Records show that infestation is still largely confined to several districts in Surrey where 300-400 buildings are known to be attacked. Outside this county, there are instances of damage in only about 30 buildings and in approximately half of these the insect was no longer active.

Damage by the house longhorn beetle in buildings may sometimes be confused with defects caused by other and less important insects. For instance, in a Hampshire house, imported softwood floor boards reported to be infested by *Hylotrupes* were, on detailed examination, found to have been damaged by a Buprestid beetle, *Eurythyrea austriaca*, not previously recorded from the United Kingdom ⁽²⁾. This insect attacks unseasoned softwoods causing a type of damage which in its early stages closely resembles the workings of *Hylotrupes*.

Biological Investigations. It is becoming increasingly difficult to secure adequate stocks of timber infested by the house longhorn beetle. Large quantities of such material are seldom available from buildings in which the insect has been reported and it is usually necessary to depend on individual samples of comparatively small dimensions from which to obtain insects for experiment. In spite of such difficulties, some 50 adults were obtained in the summer of 1953, from the stocks built up at the Laboratory during the past three years. Observations on the habits of the beetle have shown that emergence appears to be directly related to weather conditions. During the dull cloudy weather in August, 1953, few beetles made their appearance in the insectaries but a marked increase in numbers was noted during a warm sunny period in September.

Observations on the effect of temperature and humidity on the incubation period of the eggs have been continued and indicate that variations in these factors may have an important bearing on the distribution and spread of attack in the United Kingdom. For instance, it has been noted that under normal conditions of temperature and humidity in a room or in the roof of a building, the proportion of eggs which hatch is surprisingly low. At a temperature of 25°C and a relative humidity of 75 per cent, on the other hand, most eggs will hatch. Thermohydrograph records in the roof space of a building at Princes Risborough and of a house in an infested area in Surrey have shown that in the latter during 1952 and 1953, temperatures covered a much wider range and that humidity was higher than at Princes Risborough. These facts may be significant in relation to the widespread infestation in Surrey districts.

General life history studies of the insect have shown that the rate of larval growth is also closely related to temperature and humidity conditions. At 25°C and 75 per cent relative humidity, larvae have attained a length of 25 mm and more than 750 mg in weight within a period of two years, but pupation has not yet occurred. It is evident that under such conditions of constant temperature and humidity some factor required for pupation is lacking. The effect of submitting individuals to low temperatures for different periods is being investigated to promote pupation and the completion of the life cycle of the insect.

⁽¹⁾ WHITE, M. G. The House Longhorn Beetle, *Hylotrupes bajulus* L. (Col. Cerambycidae) in Great Britain, *Forestry*, 1954, **27**, 31-40.

⁽²⁾ WHITE, M. G. A Note on the Presence of *Eurythyrea austriaca* L. (Col. Buprestidae) in Silver Fir from Yugoslavia. *Ent. mon. Mag.*, 1953, **89**, (4th series, **14**), 31-32.

Further work has been carried out on the nutritional value of different zones of sapwood and experiments have been started to determine the food requirements of the larvae by inserting newly emerged individuals (egg-larvae) in samples of Corsican pine from which cell contents had been removed by leaching with water or acetone. A preliminary examination has shown that larval development has been greatly retarded in the water-extracted samples and that in those extracted with acetone the rate of larval growth is only slightly less than in the controls.

Laboratory Tests of Wood Preservatives

The exploratory work referred to in the last Annual Report (p. 36) to investigate the larval transfer technique using first stage larvae of the house longhorn beetle and larvae of varying size of the common furniture beetle for the evaluation of wood preservatives and insecticides has been continued during the year. Work has also been started on the transfer of *Lyctus* larvae inserted in oak sapwood blocks of adequate starch content. This method of determining the toxicity of wood preservatives to *Lyctus* was used but discarded by workers in Australia some years ago. With the increased knowledge of the food requirements of *Lyctus*, however, re-investigation of the value of such a method has been considered worthwhile. In the recent investigations at the Laboratory it has been found that by using a tapered type of hole and by inserting newly emerged (egg) larvae of the house longhorn or larvae of the common furniture or *Lyctus* beetles varying in weights from 1.0-2.5 mg, 80-100 per cent of the individuals became successfully established; larvae of weights above 2.5 mg were inclined to pupate immediately, before any boring had taken place.

With such information available, it has been possible to set up some preliminary tests with larvae of the common furniture beetle and the house longhorn beetle, using samples of Scots pine sapwood impregnated with different concentrations of a water soluble wood preservative. Ten common furniture beetle larvae were inserted in blocks impregnated with solutions at concentrations of 1.0, 0.5, and 0.025 per cent preservative giving dry salt retentions of 7.7, 3.8 and 0.19 mg/cc respectively. These test blocks, together with controls were kept at 22°C and 85 per cent relative humidity and were cut up for detailed examination after 12 or 33 weeks. The results have shown that no larvae survived in blocks treated with concentrations of 1.0 and 0.5 per cent, but at the lowest concentration (0.025 per cent) living larvae were present, but were of an average weight much below that of larvae in the control samples, survival being 43 per cent in treated samples as compared with 65 per cent in controls. A further test was carried out using concentrations of 0.5, 0.18, 0.0675 and 0.025 per cent, and test blocks cut up after 12 and 18 weeks. As in the first test, no larvae survived at the highest concentration, but at the two lower concentrations 60 and 66 per cent of the larvae survived respectively, whilst 83 per cent of the larvae inserted in control blocks were recovered.

These figures show a varying, but comparatively high mortality in the controls and support some of the earlier objections to this method of evaluating preservatives in relation to attack by the common furniture beetle.

A similar test is in progress at 25°C and 75 per cent relative humidity using newly emerged (egg) larvae of the house longhorn beetle and Scots pine impregnated with the same wood preservative at similar concentrations. The results so far available have shown that no larvae survived in one of the samples impreg-

nated with a concentration of 0.5 per cent, but that larvae were present in samples treated with the lower concentrations although survival and larval size were much less than in the controls. A number of samples have still to be examined and results are therefore not yet complete.

The Death-watch Beetle, Xestobium rufovillosum, and H.M.S. Victory

Since 1933 the Laboratory has, at the request of the Admiralty, carried out regular inspections of the timbers of H.M.S. *Victory* to advise on eradication and control of the death-watch beetle. At the suggestion of the Laboratory a special meeting under the chairmanship of the Admiral Superintendent, H.M. Dockyard, Portsmouth, was convened in April 1953 by the Director of the National Maritime Museum, Greenwich, to review the treatments hitherto employed and to consider new suggestions, including the use of X-rays, which had been recently put forward by an outside authority as an improved means of destroying insects. It was decided that insufficient information was at present available on the use of such a method of dealing with infestation by wood-boring insects in timbers of such large dimensions as those in the ship to justify such treatment at present. The Laboratory was, however, asked to enquire further into the possibilities of such a means of control. In the meantime, the Laboratory proposed that fumigation with methyl bromide should be considered as a means of at least reducing the population of death-watch beetles on the ship. Accordingly, a further visit was paid along with a senior officer of the Pest Infestation Research Laboratory, to determine the practicability of fumigation under the special conditions peculiar to H.M.S. *Victory*. The conclusion was reached that treatment was worthwhile if certain precautions and preparations were undertaken. A report setting forth the joint recommendations of this Laboratory and the Pest Infestation Laboratory has been submitted to the authorities concerned.

Investigations on Timber Insects in West Africa

The West African Timber Borer Research Unit, set up by the Colonial Research Council in 1952, and to which reference was made in the last Report, was stationed at Princes Risborough until July 1953, for organization and training under the general supervision of the Officer-in-Charge, Entomology Section. During this period, a series of visits was undertaken by him and the senior member of the Unit to establish direct contact with Belgian and French workers on timber insect problems with special reference to ambrosia (pinhole borer) beetles in their West African Colonies and to obtain information on related investigations in progress in Belgium and France. Two members of the Unit left for the Gold Coast in July, 1953, the third remaining at Princes Risborough to investigate some of the more fundamental aspects of the problem of infestation of timber by these insects.

Windblown Timber in Scotland

A senior officer of the Entomology Section spent a week in July, 1953, with the Forestry Commission's bark-beetle survey team operating in the gale-damaged coniferous woodlands on Deeside, Scotland, to collect information on the incidence of infestation by wood-boring insects and to assess the possibilities of a build-up in population and damage during the next few years. The indications are that the present speed of extraction and conversion is likely to prevent any serious increase but that the position should be more clearly defined in the summer of 1954.

Advisory Work in Entomology.

Advisory correspondence, although slightly less than in 1952, has again been heavy, 1,247 enquiries having been dealt with. These have followed the usual pattern of past years, information being sought on identification of cause of damage in timber before or after use and advice requested on methods of prevention and control. The following are two common enquiries which are of special interest at the present time:—

- (1) Information sought on how to recognize and prevent damage by *Sirex* wood wasps in softwood timbers, packing cases and manufactured goods for export to Australia. Such enquiries arose out of the recent intensification of Australian quarantine measures against importation of wood-boring insects.
- (2) Advice on prevention and control of infestation by *Lyctus* powder-post beetles in wooden pallets used in rack storage of a variety of goods. The use in the manufacture of pallets of untreated sapwood of *Lyctus*-susceptible hardwoods has led to trouble from these insects and to damage by emerging beetles to clothing or other articles stored in direct contact with attacked timber. A recurrence of active *Lyctus* infestation in Australian packing cases containing tinned food has been an added complication in some stores.

Inspections

It has again not been possible to meet the demand for inspections of insect-infested property, but 16 inspections have been carried out during the year. Rochester Cathedral, Sherborne Abbey, Cardiff Castle, and the Royal Haslar Hospital, Gosport, were amongst the buildings inspected.

CHEMISTRY

Wood Polysaccharides

The importance of the polysaccharides other than cellulose, which form a substantial component of all woods, has been widely emphasized in recent years, particularly in the fields of pulp, paper, and fibreboard technology. Little attention has been given to the possible significance of these components in connexion with the liability of timbers to attack by chemicals, fungi, and insects, and it is evident that a fuller knowledge of the chemical nature of these "hemicelluloses" cannot fail to be of value. This renewed interest in the hemicelluloses coincides with the introduction of the techniques of partition chromatography, which have proved so valuable in carbohydrate chemistry, and these methods are being applied to the examination of the hemicellulose fractions which can be isolated from wood by different procedures.

Hemicelluloses from Beech

Continuing the studies on beech polysaccharides, hemicelluloses B and C have now been isolated. Beech wood sawdust (20-60 mesh; 1 kg) was exhaustively extracted with alcohol-benzene and then with 0.1 N sodium hydroxide followed by 1 N sodium hydroxide at room temperature. This removed "Hemicellulose A." The residual wood was washed with acetone and air-dried (821 g; moisture 14.3 per cent; lignin 22.1 per cent). This product (809 g) was delignified with chlorite, washed with water and acetone and air dried (502 g, dry weight; lignin

2.3 per cent). The product (492 g) was exhaustively extracted with cold 4 per cent sodium hydroxide, and the hemicellulose (B) precipitated from the extract with acetic acid and an equal volume of ethanol. Yield 25.6 g, $[\alpha]_D^{19} -44^\circ$ (c, 0.3 in 4 per cent NaOH). Hydrolysis gave xylose along with small amounts of glucose, galactose and rhamnose. The last-named sugars were removed by repeated purification by means of the copper complex. The final product (13.8 g) showed $[\alpha]_D^{19} -62.5^\circ$ (c, 0.4 in 4 per cent NaOH) and pentosan 82 per cent. The material probably contains uronic acid residues.

The residual wood (420 g dry weight) was extracted with 10 per cent sodium hydroxide as before to yield a polysaccharide (C) which on hydrolysis gave xylose and uronic acid along with minor amounts of other sugars.

These fractions will be thoroughly purified, and their structure will be studied. Comparison of the products A, B and C may give some useful information about the hemicellulose—lignin relationship.

Softwood Mannan

A polysaccharide containing mannose and glucose units only has been isolated from Sitka spruce. The sawdust was extracted successively with alcohol-benzene, cold water, hot water, 0.1 N sodium hydroxide and 1 N sodium hydroxide. Only small amounts of material were dissolved out by these solvents. The residual wood was delignified with sodium chlorite to a lignin content of 5.5 per cent and the product was extracted first with 4 per cent sodium hydroxide and then with 24 per cent potassium hydroxide. In each case about 3 per cent of soluble hemicellulose was removed; both materials, on acid hydrolysis, yielded galactose, glucose, mannose, arabinose and xylose, identified on the paper chromatogram. The remaining holocellulose was completely delignified by chlorite treatment and was then extracted at room temperature with 10 per cent sodium hydroxide. This treatment yielded a polysaccharide which was purified by several re-precipitations from 8 per cent alkali with Fehling's solution. Hydrolysis of the purified material gave glucose and mannose in approximately equal proportions, while a trace of xylose was present. The sample has been sent to Professor E. L. Hirst at Edinburgh University for further investigation.

Saponins from Morabukea

Earlier work ⁽¹⁾ has shown that the timbers *mora* (*Mora excelsa*) and *morabukea* (*M. gonggrijpii*) each contain in their heartwood appreciable quantities of saponins. These substances are glycosides of the triterpenoid type, that from *mora* yielding on hydrolysis a new triterpenoid acid, named morolic acid, together with a smaller proportion of oleanolic acid, while the saponin from *morabukea* yields only oleanolic acid. Although considerable attention has been devoted to the study of the aglycones of the triterpenoid saponins, very little is known concerning the sugar portion of the molecules of these natural products. A detailed investigation was therefore undertaken to determine the types and mode of linkage of the sugars present in the *morabukea* saponin, and a report of the preliminary work has been published elsewhere ⁽²⁾.

The material investigated was shown to be a mixture, though no fractionation of the individual components has been achieved so far. Hydrolysis of the product

⁽¹⁾ Forest Products Research, 1948, 32; 1949, 35-36; 1950, 44. London, H.M.S.O.

⁽²⁾ LAIDLAW, R. A. Wood Saponins, Part I. A Preliminary Investigation of the Saponins from *Morabukea* (*Mora gonggrijpii* (Kleinh.) Sandwith). *J. Chem. Soc.*, 1954., 752-757.

gave oleanolic acid, galactose, glucose and xylose in a ratio of approximately 1:0.4:3:2. From these figures and from the results of methylation experiments, the general nature of the saponin molecules was shown to be unexpectedly complex. Most of the glucose residues were found to be present as "end-groups", though the presence of some 1-3-linked glucose units was demonstrated. The xylose residues were found to be triply-linked, some through positions C₁, C₂ and C₄, and some through C₁, C₃ and C₄. If we neglect the presence of galactose residues, many of the properties of the material can be explained by a structure wherein oleanolic acid is linked through its hydroxyl group to the reducing group of a branched-chain oligosaccharide containing glucose and xylose units. The precise arrangement of the constituent sugar residues within the molecules cannot be decided on the evidence available; partial hydrolysis of the saponin, however, gave a product containing only oleanolic acid and xylose, indicating that, in one component of the mixture, the aglycone is linked directly to xylose.

Some of the galactose residues were shown to be "end-groups," though the majority were isolated from among the products of hydrolysis of the methylated saponin as trimethyl ethers. The part played by the galactose in the molecular architecture of these saponins is not clear as yet. These residues may either form part of a "mixed" saponin, or they may be derived from a glycoside containing only oleanolic acid and galactose residues.

A more detailed knowledge of these unusual and interesting materials may throw some light on the problems of plant biosynthesis, and further investigations on their molecular structure are being undertaken.

Production of Fibreboard from Secondary Colonial Timbers

Experiments on wallaba and morabukea, in progress last year, have been continued and new investigations have been begun at the request of the Timber Research Laboratory, Malaya, on the four Malayan species, kempas (*Koompassia malaccensis*), red meranti (*Shorea leprosula*), keruing (*Dipterocarpus crinitus*), and balau (*Shorea laevis*).

A 12-inch laboratory model attrition mill has now been installed to assist in this work, together with a Williams precision freeness tester. By selecting suitable conditions for the freeness test it has been found possible to detect and measure small but critical differences in the freeness of fast-running pulps which are not revealed by the Schopper-Riegler test used hitherto. This has enabled a closer study to be made of the defibration and refining of a series of experimental pulps made from morabukea and kempas. As a result, high-strength boards have been made from chips of both species cooked with as little as 3.5 per cent sodium sulphite. The necessary strength characteristics were obtained by means of preliminary defibration of the cooked chips under carefully controlled conditions in the disc mill, followed by very light refining treatments in the beater. This was effected in both cases without lowering the freeness beyond what is considered to be a reasonable level for large scale production requirements.

During the pressing of these boards it was found possible, within certain limits, to increase the ultimate strength and also to improve the water resistance and the uniformity of surface texture by bringing the wet mat more rapidly to the operating temperature and pressure in the hot press. To achieve this the mats were cold pressed to a pre-determined water content before transfer to the hot press. Heat and pressure were then applied progressively up to the working maxima and no "breathing" was allowed.

The effects of various sizing agents have been studied on the same series of pulps, as well as heat tempering of the finished boards. The most satisfactory combination of high strength and low water absorption so far obtained was achieved by spraying the hot boards with small quantities of a drying oil from a fine spray, followed by a short conditioning period and a hot air treatment at 180°C. Boards so treated met the requirements of B.S. 1142 : 1953 ("Fibre Building Boards") in both strength and water resistance.

Preliminary cooking and defibering experiments have been carried out on the other three Malayan timbers mentioned above, and hardboards have been made from the resulting pulps. Further work will be necessary on each of these species, however, to apply fully the knowledge gained from the experiments on morabukea and kempas. It is probable also that the results already reported for wallaba may be improved upon in the light of this experience, both in respect of quality and reduction of chemical costs.

Extractives of Shorea species

In conjunction with the investigations on the suitability of certain Malayan timbers for production of hardboard, referred to above, an examination of the minor components of these timbers is being undertaken to find whether any substances of outstanding interest or of potential value are present in them.

Small scale extractions were carried out on two species of *Shorea*, namely *S. leprosula* (dark red meranti) and *S. laevis* (balau). The red meranti was extracted in the form of sawdust in a Soxhlet extractor, and the samples of balau were extracted as chips in a vapour phase extractor. The amounts of material extracted, expressed as a percentage of the dry weight of wood, are given in the following table. The logs of balau also contained pockets of a light-coloured resin, particularly in cavities resulting from insect attack.

				<i>Dark red meranti</i>	<i>Balau</i>
Per cent soluble in	alcohol-benzene (1:2) ..			5.09	3.00
" "	chloroform			2.90	0.46
" "	petroleum ether (b.p. 40-60°C)			—	0.11
" "	" " (b.p. 60-80°C)			1.81	—
" "	ether			2.83	0.91
" "	alcohol			6.56	4.9
" "	water			4.02	2.3

Large-scale extractions were carried out on the red meranti, using the following solvents in succession: petroleum ether, ether, alcohol, water.

Petroleum ether (b.p. 60-80°C). Extraction of 1 kg of wood chips (moisture content 12.9 per cent) for 16 hours in a vapour phase extractor removed 1.78 per cent of the weight of wood. The extract was evaporated and separated by treatment with cold alcohol into an insoluble white solid, softening at 90°C (41 per cent), and a yellow oil (59 per cent). Saponification of the latter and extraction with ether showed it to consist of an unsaponifiable resene fraction (57 per cent) and a saponifiable fraction (43 per cent) yielding 55 per cent of resin acids.

Ether. Further extraction of the chips with ether removed 1.2 per cent by weight of the wood, and the extract was similarly separated into an unsaponifiable resene (15 per cent), and a saponifiable fraction from which 85 per cent of resin acids were obtained.

Alcohol. The ether-extracted wood was then extracted with alcohol which removed a further 1.5 per cent by weight of the wood. The alcoholic extract was poured into water, filtered to remove insoluble ligneous material (60 per cent), and shaken with ethyl acetate. Crystals were deposited (10 per cent of original extract) having m.p. 131-137°C after recrystallisation from ethyl acetate, and on concentration of the aqueous solution a further crop of crystals (16 per cent), m.p. 136-140°C, was obtained. The total yield of crude crystals amounted to nearly 0.5 per cent by weight of the wood. Crystallisation from water or alcohol gave colourless hexagonal crystals, m.p. 135°C, while crystallisation from ethyl acetate produced long needles, m.p. 220°C, $[\alpha]_D - 34.5^\circ$ (c, 0.46 in alcohol). The material was soluble in warm water and dilute alkali and insoluble in acids. It reduced Fehling's solution and decolorized bromine water and acid permanganate. It is being investigated further.

Water. A final extraction of the wood with water removed a further 0.40 per cent of material consisting largely (65 per cent) of humic acid-like substances. The clarified solution contained no free sugars.

Advisory Work in Chemistry

Although the amount of advisory work undertaken by the Chemistry Section was rather less than in recent years (193 enquiries were dealt with by letter), the subject matter of the enquiries remains very varied.

PHYSICS

The Specific Heat of Wood

The specific heat of dry wood was investigated some 40 years ago by Dunlap⁽¹⁾, who found that its value increased linearly with temperature and was approximately independent of species. The effect of moisture content has not so far been studied, but Kollman⁽²⁾ has suggested that the specific heat of wood containing moisture can be calculated from a simple mixture law, and, on this basis, the specific heat S_u is given by

$$S_u = \frac{S_o + u}{1 + u}, \quad (1)$$

where S_o is the specific heat of the dry wood, and u is the moisture content (g water/g dry wood).

However, departures from the mixture law have been reported for many hygroscopic materials, including dried foods, starch, cellulose pulp and gelatin, and accordingly, experiments have been carried out on wood flour to see to what extent the mixture law is applicable.

In such experiments, it is desirable that any heat changes shall take place as rapidly and as uniformly as possible, and a calorimeter based on a design by Griffiths⁽³⁾ has been built to ensure that these conditions hold. The fine sawdust is contained in the air-tight calorimeter, a known quantity of heat is developed electrically, and the temperature rise is measured with a resistance thermometer; the calorimeter is kept in motion so that the sawdust is continuously mixed during the experiment.

The results at a mean temperature of 27°C show considerable departures from the mixture law (Fig. 5). The figure refers to beech, but the results for oak

⁽¹⁾ DUNLAP, F., *Bull. U.S. For. Serv.*, No. 110 (1912).

⁽²⁾ KOLLMANN, F. *Technologie des Holzes*, 2nd edn., Vol. 1, p. 520. Berlin, Springer, 1951.

⁽³⁾ GRIFFITHS, E. *Heat Insulators. Spec. Rep. Fd. Invest. Bd, Lond.* No. 35 (1929).

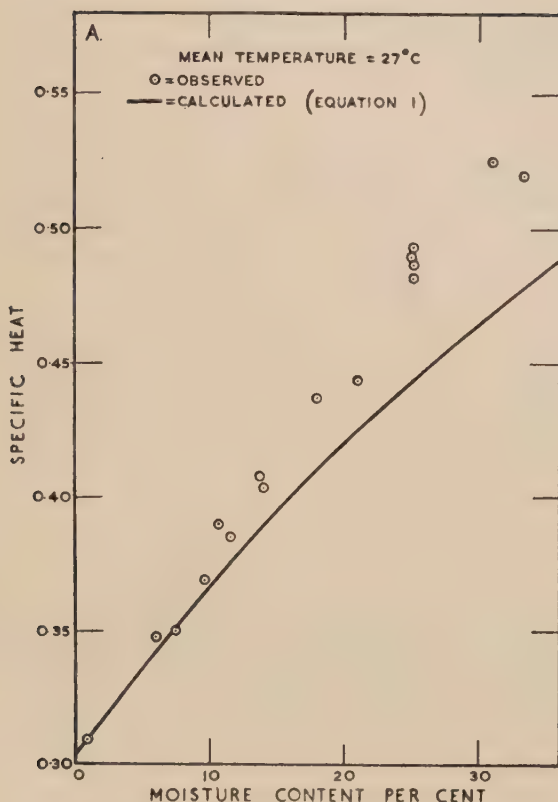


FIG. 5. SPECIFIC HEAT OF BEECH SAWDUST

show a similar trend. The effect of temperature has also been investigated. The experimental difficulties increase as the temperature rises, and some of the individual results are rather scattered. Nevertheless it appears that the specific heat increases with temperature at all moisture contents; this increase is such that departures from the mixture law become more pronounced as the temperature rises.

It will be seen from Fig. 5 that the observed specific heat is greater than the calculated value, and this is in agreement with the observations for most other similar materials. If it is assumed that the specific heat of the wood substance is the same at all moisture contents, the experimental curve of Fig. 5 can only be interpreted as indicating that the apparent specific heat of the sorbed water is greater than one. This is difficult to explain, and is contrary to what is observed, for example, with hydrated salts, for which the apparent specific heat of the water of hydration is about 0.5. In view of the high latent heat of vaporisation of water, the evaporation of only a small quantity of water during the experiments could appreciably affect the measured specific heat, and in the right direction, but calculation and experiment show that the maximum amount of water which could evaporate would be too small to account for the discrepancies. One explanation which has been suggested is that there is a change of state of the sorbed water on heating, involving an absorption of heat. If this explanation

is correct, it appears that any such change might be reflected in a change of heat of wetting of wood with temperature, and experiments to test this possibility are under consideration.

The Effect of Shear on the Frequency of Vibration of Wooden Beams

The influence of vertical shear on the static deflection of horizontal beams is well known; its effect is to produce a deflection of the beam additional to that caused by the applied bending moments. The four-point loading test is specifically used in some measurements to eliminate this effect, since shear is absent from the specimen between the inner two points.

Vertical shear also influences the frequency of bending vibrations of beams in a way which is closely related to the static effect. The theory of the bending vibrations of a long slender beam was worked out by Rayleigh⁽¹⁾ and allows the frequencies of the fundamental and higher modes to be calculated in terms of the modulus of elasticity and the dimensions of the bar. Rayleigh's treatment did not take shear into account, and more recently, several workers have modified this theory to allow for the effect of shear in the bar. It turns out that the frequency of vibration is reduced by the existence of the shear; the reduction is normally small for the fundamental, but may become appreciable if the length/thickness ratio of the bar is low. The reduction in frequency, however, increases rapidly with the order of the mode, and may be very large even for a long thin rod if the mode is a high one. The magnitude of the reduction depends, among other factors, on the ratio of elasticity modulus to shear modulus, and it has been suggested that it might be possible to measure both the elasticity and the shear modulus on a single specimen of wood, the elasticity modulus from the frequencies of the lower modes of vibration and the shear modulus from the reduction in frequency of the higher modes.

In order to check the theoretical predictions, an apparatus has been assembled in which wooden beams can be driven in vibration, and the response of the beam detected as the frequency of the drive is varied. Both the drive and the detection are carried out electrically, and, to provide an accurate reference frequency, an electrically driven tuning fork has been built and incorporated in the apparatus.

Experiments have so far been carried out on a bar of brown sterculia the cross section of which measured 5.03 x 2.51 cm and the initial length 183.1 cm. The bar was supported in the apparatus in such a way that its ends were free, and the frequencies of the successive modes of vibration measured by observing the driving frequencies at which the response of the bar was a maximum. Lengths of about 30 cm were then cut successively from the bar, and the frequencies determined for each new length. The observed frequencies (f_o) for three of the lengths are given in Table 5, together with the frequencies (f_t), calculated from the uncorrected Rayleigh formula and from this formula, corrected for the effect of shear (f_e). The value of elasticity modulus used in the calculations was obtained from the frequencies of vibration of the fundamental modes (mode 1), for which the shear correction is small, or even negligible. The shear modulus was estimated by cutting specimens from the surplus portions of the bar and measuring the frequencies of torsional vibration. It will be seen that the agreement between the corrected Rayleigh frequencies and the observed values is good, but that the corrected frequencies are often of the order of 1 per cent low. From the point of view of interpreting the observed results, this is relatively

(1) LORD RAYLEIGH. *Theory of Sound*. Ch. VII. London, Macmillan, 1877.

unimportant, but if the observations are used to estimate the shear modulus, it is more serious. In this case, shear modulus is calculated from the quantity $(f_i/f_o)^2 - 1$, and a 1 per cent error in f_o can accordingly lead to a considerably larger error in the shear modulus.

TABLE 5
Frequencies in Cycles per Second

Length (cm)	183.1			105.2			74.3		
Mode Number	f_t	f_c	f	f_t	f_c	f_o	f_t	f_c	f_o
1	37.2	37.1	37.1	112.1	111.4	111.4	225	222	222
2	102.6	101.8	101.8	309	302	302	620	595	588
3	201.8	198.0	198.0	605.5	574	580	1216	1101	1110
4	332.3	322.7	323.7	100.1	916	928	2010	1714	1725
5	496.4	474.1	475.0	1496	1312	1333			
6	693.3	651	654.2						
7	923.0	848.4	855.4						
8	1186	1070	1075						
9	1481	1300	1309						
10	1809	1548	1560						

It therefore appears that, although it is possible to explain the observations in terms of the effect of shear, the method is of doubtful value for the actual measurement of shear modulus. However, work is being continued with the object of resolving the discrepancies and so improving the method when applied to the measurement of shear modulus.

Low Frequency Vibration Methods

The experiments discussed above are carried out in the region of low and medium audio-frequencies so that the specimen must be driven, and the response measured, by electrical means. For the routine measurement of elastic constants, it is simpler and more convenient to work in the subsonic region, where the frequencies of vibration can be timed directly with a stop-watch. Measurements of elasticity modulus are then normally carried out on a strip of wood clamped with its length horizontal, and a weight attached to the free end. Under some circumstances, it may be desirable to clamp the specimen with its length vertical and the weight below the point of clamping. If the length is horizontal the only force acting when the system is displaced from its equilibrium position is the elastic reaction of the bent strip. If the length is vertical, however (Plate 8) there is an additional force analogous to that acting on the bob of a swinging pendulum, which operates when the system is vibrating, and it is necessary to correct for this effect before the modulus of elasticity can be calculated accurately. An approximate correction factor was found in 1940 ⁽¹⁾, but during the past year a more exact theoretical analysis of the system has been carried out. The analysis, the results of which have been verified experimentally, shows (1) that the deflection curve of the vibrating vertical strip is approximately that appropriate to a uniformly loaded cantilever, and not that appropriate to an end-loaded cantilever and (2) that the length of the equivalent pendulum is $7l/8$, and not l as assumed in the previous derivation. (l is the length of the specimen.) In

⁽¹⁾ HEARMON, R. F. S. Elasticity of Wood and Plywood. *Spec. Rep. For. Prod. Res., Lond.* No. 7 (1948).

practice, the corrections derived from these two effects are normally small, and tend to compensate each other, but for accurate results, of course, the exact corrections should be applied.

Wood—Water Relationships

The moisture content—relative humidity relationship for beech and Sitka spruce has been measured at 35 and 75°C, in addition to the determinations, mentioned in last year's Report (p. 48), at 25 and 30°C. At 75°C the absorption and desorption curves coincide within the limits of experimental error, so that at this temperature, wood no longer exhibits hysteresis. Further measurements are now being made at 50°C to bridge the gap between the existing results.

Experiments have also been made on the effect of heating wood at 50 and 90°C in atmospheres of 30, 60 and 90 per cent relative humidity on the subsequent equilibrium moisture contents. The results confirm that appreciable reductions in this moisture content may be produced by heating, and, although the evidence is not conclusive, strongly suggest that heating under different conditions alters the shape of the isothermal to some extent.

Diffusion of Water Vapour Through Wood

The experiments on the flow of water vapour through wood discs, discussed in previous annual reports, have all been carried out with a relative humidity difference of approximately 100 per cent between the two parallel faces of the discs. This was accomplished by arranging for the wood disc to form a barrier between two spaces, the first space being kept completely dry by the presence of phosphorus pentoxide and the second kept saturated with vapour by the presence of free water. If the water is replaced by a saturated solution of, say, sodium chloride, the relative humidity difference across the specimen will be 75 per cent and the average moisture content of the disc will be about 6 per cent. On the other hand, if the phosphorus pentoxide is replaced by the sodium chloride solution, the humidity difference will be 25 per cent and the average moisture content of the disc about 20 per cent. During the past year measurements have been made of the flow of water vapour under these conditions in the three principal grain directions, at temperatures of 20, 30 and 40°C, and using saturated magnesium chloride solution (relative humidity 32 per cent) as well as sodium chloride. The measurements appear to be subject to a rather large experimental error, but indicate that in the transverse directions of wood, a given humidity gradient will produce a larger flow of water vapour at a high average moisture content than at a low one. This is in agreement with previous results, obtained here and elsewhere, which showed that the diffusion coefficient for water vapour in the transverse directions of wood increased with increasing moisture content. In the longitudinal direction, however, the present results suggest that the flow of water vapour under a given humidity gradient is much less dependent on moisture content, and hence that the longitudinal diffusion coefficient is approximately independent of moisture content.

Advisory Work in Physics

Enquiries have been answered relating to the following subjects: transmission of light through wood, swelling stresses, thermal insulation, moisture content hysteresis, applications of infra-red rays, non destructive testing, electrical properties, and flotation of logs.

EXTERNAL RELATIONS

Timbers for Testing

The general tests of timbers in hand have been brought up-to-date. No new leaflets on timbers, however, have been published as completed results will be incorporated in the revised edition of the Handbook of Empire Timbers.

Timbers recently procured for test were:—

African mahogany, canarium, okwen (Nigeria); serrette (Trinidad); sepetir (Sarawak); Canadian yellow birch, gaboona, balsa, abura, obeche, courbaril, agba (commercial source); Scots pine, birch, oak, Turkey oak, field maple, sycamore, beech, cherry, hornbeam, Norway spruce, Sitka spruce, western red cedar, and Douglas fir (Forestry Commission).

Timber Quality in Relation to Silviculture

The work in co-operation with the Forestry Commission on the quality of timber in relation to site and soil has continued. Three more parcels have been procured, two of Sitka spruce and one of Norway spruce. In addition to these, two lots of an older age group, one of Douglas fir and one of western red cedar, were obtained to study the specific gravity, volume increment, etc.

The tests on the Sitka spruce from Inverliever and Gravetye Forests were completed. They showed a marked difference between the timber of the two sites, that from Gravetye yielding considerably better timber.

A striking point regarding these two consignments was that there was very little difference shown in the strength of the Grade II joists, whereas the static bending stress on the small clear specimens of the Gravetye consignment was 7,080 Lb./sq. in., compared with those from Inverliever which was only 4,570 Lb./sq. in. This was mainly owing to the knots in the Gravetye timber being larger than those in the Inverliever although they were within the size laid down in the grading rules for the grade.

A third consignment of Sitka spruce from Drumtochty Forest, Scotland, was brought in during the year. This material was from a forest of nearly half the rainfall of Inverliever and the timber was very fast grown.

The first consignment of Norway spruce was obtained from Scotland and both the last named consignments are now under test.

The study of specific gravity, volume increment and rate of growth has been continued, and the method of arriving at the results has been revised. In each consignment five average trees are brought in, which run out to a diameter of 3 in. under bark. Discs are cut at butt or clear of butt swelling and at every ten feet up the tree. The discs after thicknessing and planing are cut round the annual ring at every fifth year starting from the bark. The specific gravity is then determined for every five-year period through the tree.

To enable forecast results to be made five trees of Douglas fir and western red cedar 50 years old were obtained from the windblown area in Scotland and are being treated as described above.

Advisory and Liaison Work

Technical enquiries dealt with by the Section were 219 in 1953.

After the gale damage in Scotland in February, 1953, many enquiries were received from landowners and the timber trade regarding the storage of the

timber while it was being logged and converted. An advisory note was prepared and circulated to all those interested.

Visits

Visits to timber merchants and factories using timber were limited owing to the amount of internal work. The works of firms engaged in the following trades were visited and inspected:

Lorry, car and bus body builders, fibreboard manufacturers, joinery and general timber merchants, film and camera manufacturers, aeroplane manufacturers, an air transport crating department, brewers, and furniture manufacturers.

Visitors

A very large number of visitors came to the Laboratory during the year. The number of those from the timber-using trades is increasing, and to accommodate them there has had to be a further curtailment of the visits by technical college students.

Commercial undertakings such as timber merchants, manufacturers, builders and architects, sent 102 representatives, which was an increase of 38 over 1952. A point worth noting is the increase in requests by firms to take a series of parties of four to six persons drawn from all levels of their staff. This development is welcomed as the men actually handling the timber make contact with the Laboratory and much useful information is interchanged.

The number of overseas visitors increased remarkably from sixty-nine to one-hundred-and-eight, representing thirty-four different countries and colonies. The visitors were from Argentine, one; Australia, three; British Guiana, two; Burma, one; Ceylon, six; Cyprus, one; Denmark, three; Eire, two; Finland, one; Germany, three; Gold Coast, seven; Greece, three; India, ten; Indonesia, five; Jamaica, one; Japan, two; Kenya, two; Malaya, two; New Zealand, one; Nigeria, two; Nyasaland, two; Pakistan, seven; Philippines, two; Poland, one; Sarawak, one; Siam, two; South Africa, three; Sudan, one; Sweden, two; Tanganyika, five; Trinidad, two; Uganda, two; U.S.A., twenty; Zanzibar, one.

Most of the visitors were timber merchants, foresters, manufacturers using timber, or engineers.

Education

The educational side of the work of the Laboratory was somewhat restricted by having to deal with visitors from the trade. Four University groups of students visited the Laboratory, totalling seventy-six students, from: London (botany); Aberdeen (forestry); Oxford (forestry), and Edinburgh (forestry). Eleven of the Timber Development Association instructors came for four days' intensive training, and one-day visits were made by members of the Institution of Woodworking, P.O. engineers from Birmingham, handicrafts officers of the Bucks' Education Authority, and other technical bodies.

During the year three students from Yugoslavia, Siam, and Burma, respectively, came to study for eight-nine months, and a Forest Officer from Tanganyika for one month.

During the year six courses were given for kiln operators; the number of trainees was forty-four. Two trainees received special instruction in Wood Bending.

The usual individual lectures to technical bodies have been given by senior members of staff, as well as two series of public lectures, under the auspices of the Ministry of Works and of the High Wycombe College of Further Education, respectively.

Publicity

Five members of the press visited the Laboratory with a view to the preparation of articles on the work. The B.B.C. made two recordings of various aspects of the work, and the Laboratory appeared once on Television.

F. Y. HENDERSON,
Director.

FOREST PRODUCTS RESEARCH LABORATORY,
Princes Risborough,
Aylesbury, Bucks.

17th March, 1954.

APPENDIX I

STAFF AT THE FOREST PRODUCTS RESEARCH LABORATORY
31st December, 1953

Director of Forest Products Research: F. Y. HENDERSON, C.B.E., D.Sc., D.I.C.

ADMINISTRATION

Assistant Director: S. T. C. STILLWELL, O.B.E., B.Sc.

Senior Principal Scientific Officers: J. BRYAN, M.Eng., A.M.Inst.C.E.;
K. T. ST. G. CARTWRIGHT, M.A., D.I.C.

Higher Executive Officer: R. D. WEEKS.

Executive Officer: MISS D. LACEY.

SECTION OF WOOD STRUCTURE

Principal Scientific Officers: B. J. RENDLE, B.Sc., A.R.C.S. (Officer in Charge);
E. W. J. PHILLIPS, B.Sc., Ph.D., A.R.C.S.

Scientific Officer: J. D. BRAZIER, B.Sc.

Experimental Officer: G. L. FRANKLIN.

Temporary Assistant Experimental Officer: MISS L. M. HOLTHAM.

SECTION OF PHYSICS

Principal Scientific Officer: R. F. S. HEARMON, F.Inst.P. (Officer in Charge).

Experimental Officers: J. N. BURCHAM, B.Sc.; J. McC. PATON.

Assistant Experimental Officer: E. H. ADAMS.

SECTION OF SEASONING

Principal Scientific Officer: W. C. STEVENS, M.A., A.M.I.Mech.E. (Officer in Charge).

Senior Experimental Officers: R. E. HODGE, Assoc.I.Mech.E.; D. D. JOHNSTON;
G. H. PRATT; N. TURNER.

Experimental Officer: A. R. DEAN.

Assistant Experimental Officer: R. H. WYNANDS.

Temporary Assistant Experimental Officer: T. R. SUCKLING.

SECTION OF TIMBER MECHANICS

Principal Scientific Officer: F. H. ARMSTRONG, M.Sc., A.M.I.Mech.E. (Officer in Charge).

Scientific Officer: A. J. COMBEN, B.Sc.

Senior Experimental Officer: A. J. FOORD.

Experimental Officers: W. T. CURRY; Miss M. E. FULFORD; J. G. SUNLEY, B.Sc.

Assistant Experimental Officers: G. R. BROCK; Miss W. M. FOGERTY.

Temporary Assistant Experimental Officer: W. T. HIDE.

SECTION OF WOOD PRESERVATION

Principal Scientific Officer: N. A. RICHARDSON, B.Sc., A.R.I.C. (Officer in Charge).

Senior Experimental Officer: D. N. R. SMITH.

Experimental Officers: D. F. PURSLOW, B.Sc., L. W. REDDING.

Assistant Experimental Officers: R. COCKCROFT; Miss E. LEE.

SECTION OF CHEMISTRY

Principal Scientific Officer: R. H. FARMER, B.A., B.Sc., D.Sc. (Tech.), F.R.I.C. (Officer in Charge).

Senior Scientific Officer: R. A. LAIDLAW, B.Sc., Ph.D.

Scientific Officer: Mrs. W. R. CARRUTHERS, B.Sc.

Experimental Officers: D. F. PACKMAN, B.E.M.; L. C. PINION, B.Sc.

SECTION OF MYCOLOGY

Senior Principal Scientific Officer: W. P. K. FINDLAY, D.Sc., A.R.C.S., D.I.C., A.I.C.T.A. (Officer in Charge).

Senior Scientific Officer: J. G. SAVORY, B.Sc.

Experimental Officer: E. C. BADCOCK.

Assistant Experimental Officer: Miss C. A. CLEMENTS, B.Sc.

SECTION OF ENTOMOLOGY

Principal Scientific Officers: R. C. FISHER, B.Sc., Ph.D., F.R.S.E. (Officer in Charge).
J. D. BLETCHLY, B.A., B.Sc., F.R.E.S.
Scientific Officer: M. G. WHITE, B.A.
Senior Experimental Officer: E. C. HARRIS.
Assistant Experimental Officer: Miss J. M. TAYLOR, B.Sc.

SECTION OF WOODWORKING

Principal Scientific Officer: P. HARRIS, B.Sc. (Eng.), A.M.I.Mech.E. (Officer in Charge).
Senior Experimental Officer: R. GOODCHILD.
Experimental Officer: H. J. ENDERSBY.

SECTION OF EXTERNAL RELATIONS

Principal Scientific Officer: F. G. O. PEARSON, B.Sc. (Officer in Charge).
Experimental Officer: Miss C. WEBSTER.
Assistant Experimental Officer: Miss H. A. FIELDING.

SECTION OF COMPOSITE WOOD

Principal Scientific Officer: R. A. G. KNIGHT, B.Sc. (Eng.), M.I.Mech.E. (Officer in Charge).
Scientific Officers: J. F. S. CARRUTHERS, B.Sc.; T. P. HUGHES, B.Sc.
Senior Experimental Officers: L. S. DOMAN; R. J. NEWALL.

SECTION OF PUBLICATIONS AND RECORDS

Senior Experimental Officer: C. J. N. MCCrackEN, B.A., Dip.For. (Officer in Charge).
Experimental Officer: C. L. STOCKER, B.A., Dip.For.
Assistant Experimental Officer: Miss E. M. M. WOOD.

DRAWING OFFICE AND PHOTOGRAPHY

Senior Photographer: W. J. BALDWIN.
Experimental Officer: E. A. STEEL, Assoc.I.Mech.E.

APPENDIX II

LIST OF PUBLICATIONS ISSUED DURING 1953

A. Stationery Office Publications

Forest Products Research 1952.

Bulletins:

- No. 26. An Atlas of End-grain Photomicrographs for the Identification of Hardwoods.
 No. 27. The Performance of Circular Plate Ripsaws. By H. J. Endersby.
 No. 28. The Strength Properties of Timber. By F. H. Armstrong, M.Sc., A.M.I.Mech.E.
 No. 29. The Strength Properties of Plywood. Part 1. Comparison of 3-Ply Woods of a Standard Thickness. By W. T. Curry.

B. Other Publications

*Leaflet:**

- No. 43. Spray Treatment for Prevention of *Lyctus* Attack in Sawn Logs. (*Revised edition.*)

Papers Published in Journals:

- ARMSTRONG, F. H. The Testing of Timber. 1. Methods of Tests of Small Clear Specimens. *Parthenon*, 1953, 27 (7), 133-141.
- BLETCHLY, J. D. A Note on the Prepupal Stage and the External Sex Characters of the Pupae of *Anobium punctatum* De G. (Coleoptera, Anobiidae). *Bull. ent. Res.*, 1953, 43 (4), 587-590.
 The Influence of Decay in Timber on Susceptibility to Attack by the Common Furniture Beetle, *Anobium punctatum* De G. *Ann. appl. Biol.*, 1953, 40 (1), 218-221.
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